Don't Miss the Perseid Meteor Shower!

ASTRONOMY®

August 1996 U.S. $3.95
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ICD 08070

A Runaway River of Galaxies

Stunning New Hubble Photos

- Astronomy from 50 Billion Miles
- Free-Form Observing

12"
10"
7"
8"
MEADE LX200 EMC

LX200

The largest-selling serious telescopes in the world.

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models ***combined***. Consider these *standard-equipment* specifications:

- **Superb Optics:** LX200 imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of over 64,350 objects in the onboard database, *to a precision of one arc-minute or better.*
- **Meade LX200 High-Precision Pointing**™ is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat that no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive**™ routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The optional #1812 Electronic DC Adapter (a compact 4 oz. unit) allows for field powering directly from an auto cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); complete operating instructions.

8" LX200 Schmidt-Cassegrain	**$2795.**
10" LX200 Schmidt-Cassegrain	**3195.**
12" LX200 Schmidt-Cassegrain	**4495.**
7" LX200 Maksutov-Cassegrain	**3295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

LX50

Advanced technology at the most affordable prices ever.

- **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel. Or use the standard-equipment 25 ft. cord to power the telescope directly from any auto cigarette lighter plug.

- **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for full dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A. Switch speeds instantly using the speed-control button on the hand controller. Dual-axis drive rate is indicated by a red LED.

- **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below)*. A North-South switch permits telescope operation anywhere in the world.

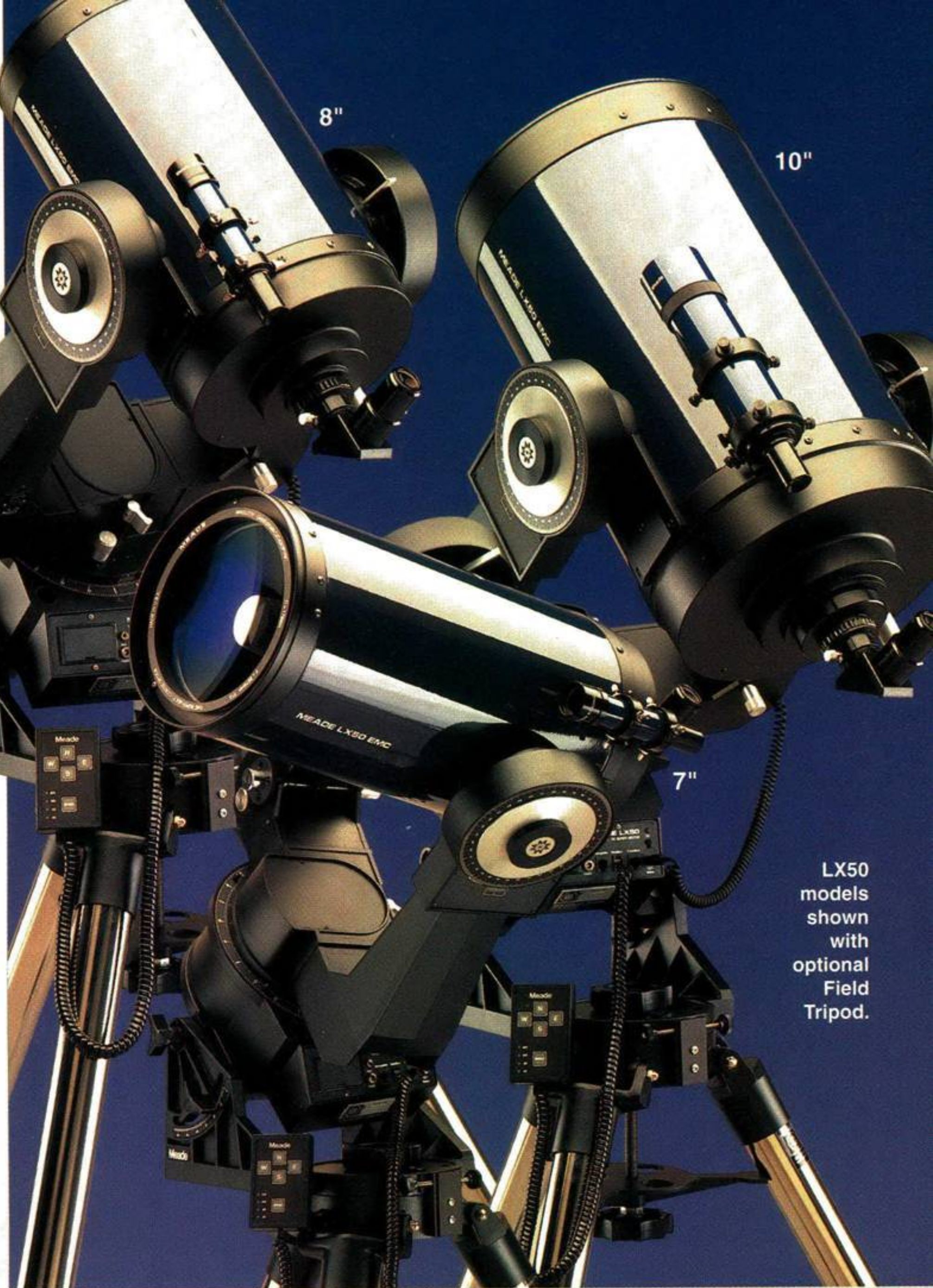
- **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.

- **Massive LX200-type Fork Mounts:** Meade LX50 mounts are manufactured of the same virgin aluminum castings as Meade LX200 Schmidt-Cassegrains. Massive, rigid mountings that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications. *No competing mid-priced equatorial mountings even come close.*

SPECIFICATIONS: 7", 8", and 10" LX50's—Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; MA25mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1395.**
10" LX50 Schmidt-Cassegrain	**1695.**
7" LX50 Maksutov-Cassegrain	**1795.**
Variable-Height Field Tripod	**295.**
7" Maksutov-Cassegrain Tube Ass'y, only	**1195.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.



LX50 models shown with optional Field Tripod.

Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), completely concealed in special LX50 encoder compartments. ■ Quick 2-star alignment. ■ Large 32-character, red-backlighted display. ■ 4-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

#2024: Magellan II for LX50's—Includes Magellan II hand controller *(right)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$495.** + $15 packing and shipping in the 48 states.

Send $3.00 to Meade Instruments for the Meade 1996 General Catalog. Prices shown are suggested U.S. mail-order retail prices.

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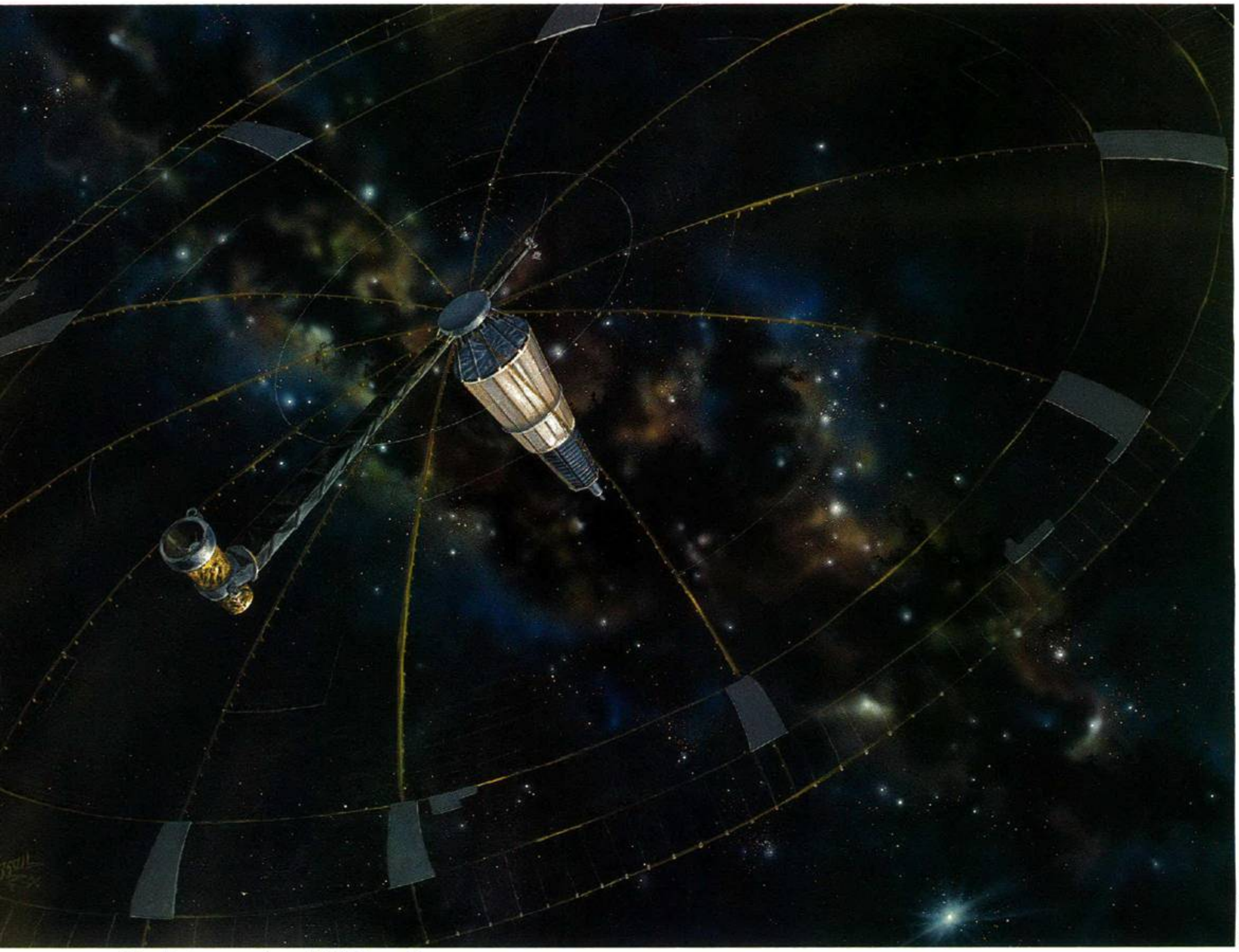

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NASA celebrated the sixth birthday of the space telescope by releasing a treasure trove of stunning images, bringing into sharp focus objects as near as Saturn and as distant as galaxy clusters. *Robert Naeye.*

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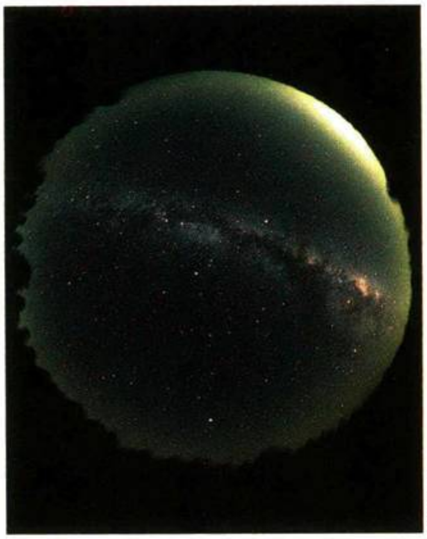
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Observers watched enthralled as Saturn turned its rings edge-on to our line of sight for the first time in 15 years. *Richard Talcott.*

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BEHIND THE SCENES

Catch Some Falling Stars

One of the things that perennially draws us to meteor showers is the potential for seeing that one breathtaking, heart-stopping, eye-popping fireball that splits open the inky sky with a lance of light and evokes the *Hallelujah Chorus*. Although such displays are admittedly the exception rather than the rule, some annual meteor showers are more likely to produce a meteoric epiphany if you're patient and vigilant. The Perseid meteor shower is one of those.

Of the nearly 60 known annual meteor displays, the Perseid shower is one of the Northern Hemisphere's most active. Each year this shower typically exhibits a large number of bright meteors, any one of which may explode or fragment, leaving behind brief smoke trains. The Perseids are also famous for producing long-duration meteors. During its 1993 showing, for instance, I vividly recall seeing one meteor appear in the northeast, cross overhead, fragment, and vanish in the southwest.

This year the shower peaks at 12h UT August 12, which is 8 a.m. Eastern Daylight Time. Still, the hours leading up to the peak will be untainted by moonlight; even the faintest meteors should be routinely visible from a relatively dark sky site.

Don't be discouraged if your skies are cloudy the morning of the 12th. The shower is active over a period of about a month, so the week before and after the peak should also be good for meteor watching. For more on observing the Perseid shower, see "A Banner Year for the Perseids" in the Sky Almanac on page 64.

New Staff Member

ASTRONOMY has a new assistant editor and resident amateur astronomer: Patti Kurtz. Patti, who hails from Denver, Colorado, organized astronomy programs and star parties there for Starlight Adventures Unlimited. A tireless, well-rounded observer, Patti enjoys all aspects of the astronomy hobby, including the fun, camaraderie, burned coffee, and stale donuts one often encounters at 3 o'clock in the morning. Her real passion, however, is viewing the universe through the biggest Dobs she can find — we're talking 30- and 36-inchers here!

ASTRONOMY: William Zuback

Patti Kurtz

Unfortunately, the weather in Wisconsin doesn't always cooperate with her deep-sky endeavors. (The sky here can be completely overcast, with the forecast calling for increasing clouds.) Still, we think we can keep her happy by sending her to amateur meetings and star parties in quest of megadobs.

In addition to writing and editing, Patti will be stoking ASTRONOMY with her cache of good ideas. In fact, one of her ideas appears on page 52 of this issue, "Catch a Perseid on Film." We look forward to realizing many more of Patti's great notions in future issues.

Sincerely,

Jeff Kanipe

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The Audit Bureau

MEADE ETX

90mm Maksutov-Cassegrain

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Meade ETX Astro Telescope. Shown with optional #64 Photo Adapter.

SPECIFICATIONS: ETX Astro Telescope— Includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; equatorial fork mount with slow-motion controls, locks, and setting circles in R.A. and Dec; table tripod with elevation scale on center tripod leg; motor drive system with internal battery compartment accepting three (user-supplied) AA-size batteries; 8 x 21mm achromatic erect-image viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); operating instructions. *Net weight 9 lbs.* **$495***
(+ $20 packing and shipping in the 48 states)
*Suggested U.S. mail-order retail price.

Now you can have diffraction-limited imaging and ultraportability ...at only *$495*, *complete!*

The revolutionary Meade ETX goes anywhere with you at a moment's notice and presents the finest optical images ever made available in an ultraportable telescope.

Optical System: Manufactured at the Meade Irvine, California facility, ETX diffraction-limited optics produce images so high in contrast, brightness, and resolution that the ETX consistently outperforms telescopes of much larger apertures. **Equatorial Fork Mount:** Precise polar alignment in *seconds,* just by extending the center tripod leg to read your latitude on the inscribed scale. **Cordless Motor Drive:** The internal drive system operates from 3 AA-size batteries that power the motor drive for more than 50 hours. A North-South switch permits operation anywhere in the world. **Flip-Mirror System:** Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #932 45° Erecting Prism or for photography with the optional #64 Photo Adapter. **Standard accessories** include a Series 4000 Super Plössl 26mm eyepiece and 8 x 21mm erect-image viewfinder.

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MEADE
MEADE 127ED/APO EMC
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Meade Model 127ED: 5" *ED* Apochromatic Refractor. Shown with optional #1697 Computer Drive System.

Background image: **the Omega Nebula (M17) —** A 5-minute image by Jack Newton using the Meade 7" *ED* Apochromatic Refractor and Meade Pictor 1616 CCD Imager.

ED APOCHROMATIC REFRACTORS

"This is the best black-and-white CCD image of M17 that I have ever taken with any telescope. I just couldn't believe that this could be done in a 5-minute shot with a CCD camera and a 7" refractor. I'm amazed at how the telescope performs, even against my own 25" Newtonian." **—Jack Newton**

Fortunate indeed is the observer with a Meade *ED* Apochromatic Refractor at his or her disposal, for these are professional-class instruments capable of serious research. Observe structural detail and color variations within Jupiter's Red Spot and at the boundaries of 8 to 10 cloud belts; resolve all three of Saturn's main rings and substructures within the rings themselves. *Simply put, if you're looking for the finest, textbook-perfect, ultra-high-resolution, high-contrast imaging of the skies that astronomical instrumentation, of any type, can provide, then a Meade ED Apochromatic Refractor is for you.*

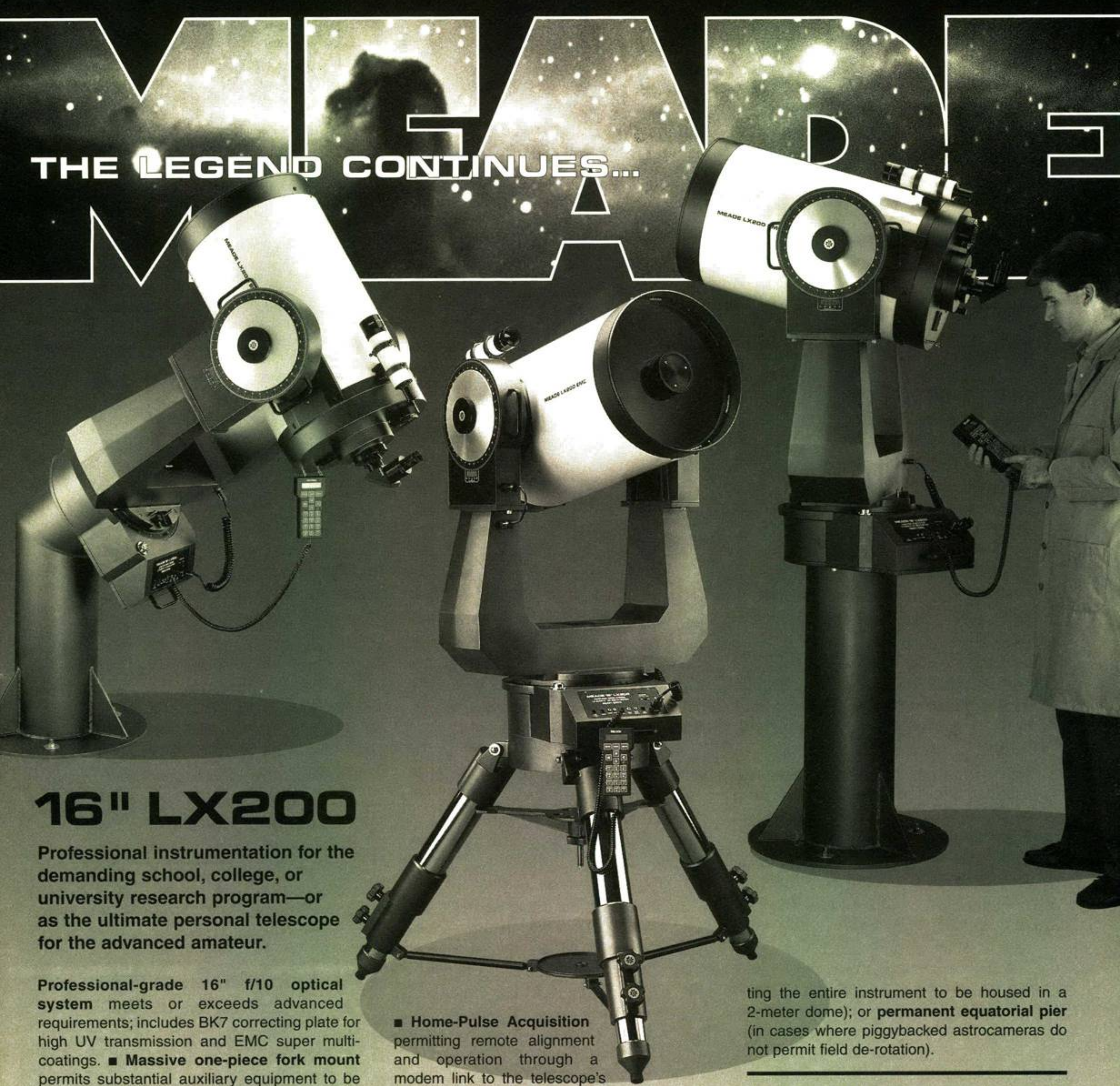
Use the massive Meade **LXD 650** (4", 5") or **LXD 750** (6", 7") equatorial mounts in conjunction with the optional **#1697 Computer Drive System** to slew the telescope across the sky and computer-point the instrument, automatically, *to a precision of one arc-minute.* ***Meade LXD mounts are the only commercially-available German-type mounts capable of such a feat.*** Actuate any of 9 pushbutton-controlled drive speeds (from 2x photoguide to 8°/sec. fast-slew) on both axes, automatically, to locate and center any object directly from its input R.A. and Dec. Or use the onboard database for even faster object centering. Included with the #1697 CDS, the Meade **Smart Drive**™ assures the extremely low periodic error essential to research-level photographic or CCD imaging.

More than 40 Meade optional accessories are available to suit virtually any observing, photographic, or CCD imaging requirement.

Supplied complete per catalog specifications:

4" f/9 Model 102ED	**$2495.**
5" f/9 Model 127ED	**2995.**
6" f/9 Model 152ED	**4495.**
7" f/9 Model 178ED	**5495.**
#1697 Computer Drive System	**695.**

Packing and shipping in the 48 states: 4"—$105; 5"—$125; 6"—$185; 7"—$215.



16" LX200

Professional instrumentation for the demanding school, college, or university research program—or as the ultimate personal telescope for the advanced amateur.

Professional-grade 16" f/10 optical system meets or exceeds advanced requirements; includes BK7 correcting plate for high UV transmission and EMC super multi-coatings. ■ **Massive one-piece fork mount** permits substantial auxiliary equipment to be piggybacked with rock-solid stability. ■ **Large 11" worm gears** on both axes, with factory-programmed Smart Drive™; periodic error less than 5 arc seconds. ■ **Automatic GO TO capability** to any object in the onboard 64,350-object database or to any input R.A. and Dec. ■ **High-Precision Pointing™** to within one arc-minute in the GO TO mode. ■ **DC servo drive systems** with integrated encoders and planetary gearboxes; encoder resolution: 0.13 arc secs. ■ **Six pushbutton-controlled drive-speed rates,** from photo-guide to fast-slew on both axes, simultaneously. ■ **Micro-processor controlled sidereal-rate tracking** in AZ or EQ modes with quartz accuracy. ■ **Home-Pulse Acquisition** permitting remote alignment and operation through a modem link to the telescope's RS-232 interface. ■ **Control panel connectors** for optional systems including CCD autoguiders and imagers, electric focuser, and the Meade **#1222 Field De-rotater** for long-exposure astrophotography in the AZ mode. ■ Available with **supergiant transportable field tripod** (2-person field set-up in less than 10 minutes); **permanent altazimuth pier** (permitting the entire instrument to be housed in a 2-meter dome); or **permanent equatorial pier** (in cases where piggybacked astrocameras do not permit field de-rotation).

The Meade 16" LX200 is in continuous production at the Meade Irvine, Calif. factory. **Delivery time:** 4 to 12 weeks. **Price:** $14,950, complete with supergiant field tripod, plus $385 packing and shipping in the 48 states; prices slightly higher with permanent altazimuth or equatorial pier.

For your free copy of the 94-page **Meade 1996 General Catalog** write Meade Instruments or contact your authorized Meade Advanced Products Dealer.

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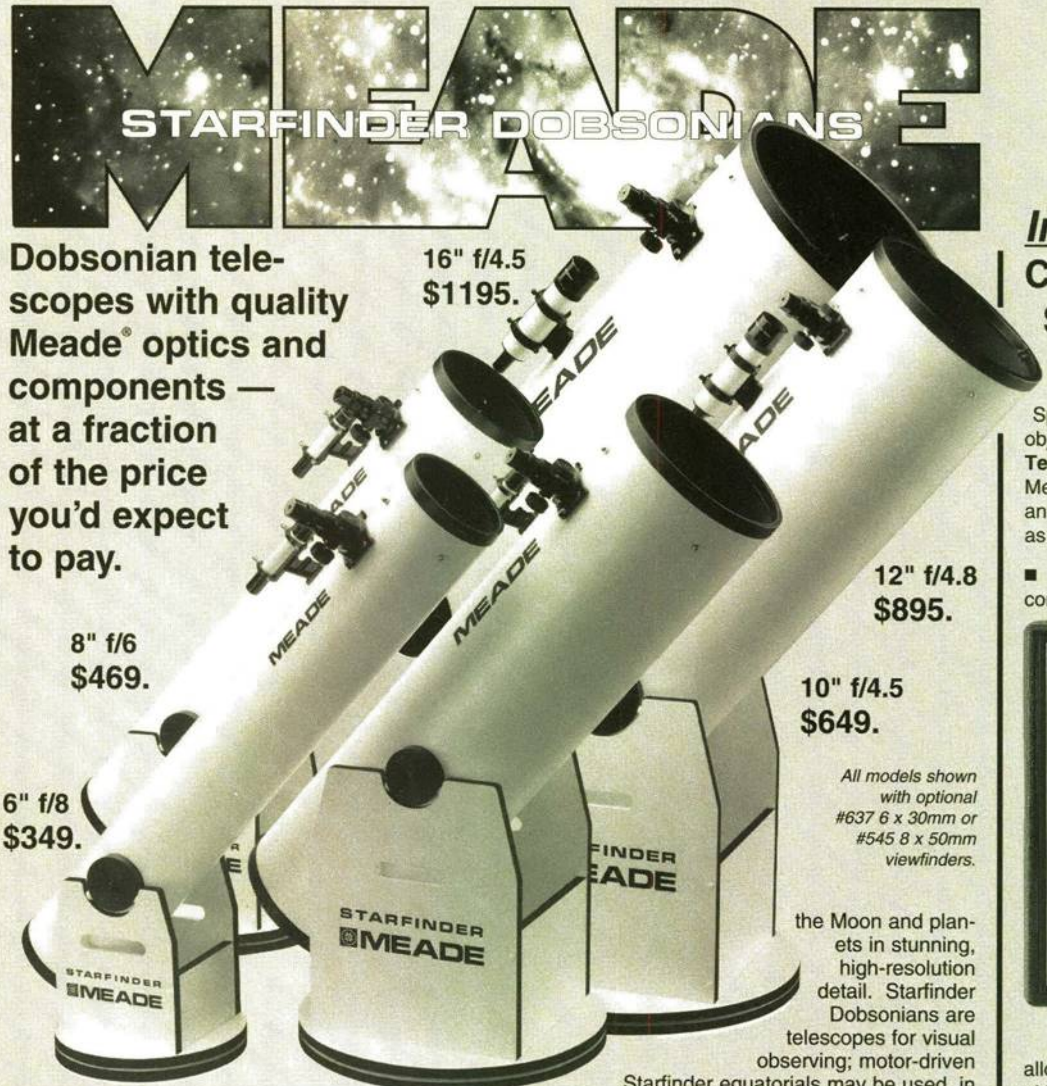

Dobsonian telescopes with quality Meade® optics and components — at a fraction of the price you'd expect to pay.

16" f/4.5
$1195.

12" f/4.8
$895.

10" f/4.5
$649.

8" f/6
$469.

6" f/8
$349.

All models shown with optional #637 6 x 30mm or #545 8 x 50mm viewfinders.

Compare *feature-for-feature* with other similarly priced Dobsonians!

- **Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass:** Unlike the plate glass optics of other Dobsonians that can become thermally unstable (especially in larger apertures), Meade Dobsonians are made of Grade-A, fine-annealed Pyrex—the exact same professional-quality optics used on Meade Starfinder Equatorials.
- **Precision Components:** Including a full-size rack-and-pinion focuser (1.25") with 2.6" travel and fully-adjustable *4-vane* secondary mirror system.
- **Rigid, Durable, Beautiful Dobsonian Mountings**, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the location and tracking of celestial objects.
- **Optical Tubes:** Starfinder Dobsonians include the same strong, spiral-wound optical tubes used on Starfinder Equatorials *(right)*. All telescopes include a multi-coated MA25mm eyepiece; each tube is factory pre-drilled for the optional 6 x 30mm or 8 x 50mm viewfinder.
- **Performance!** A Meade Starfinder Dobsonian or Equatorial opens up the skies to an extremely wide range of serious visual observing: all 110 Messier objects, thousands of NGC objects—nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning, high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder equatorials may be used, in addition, for lunar and planetary photography and even for limited deep-space photography.

Packing and UPS Shipping Charges to any address in the 48 states: 6"–$39; 8"–$49; 10"–$69; 12.5"–$79. 16"–$45 packing, shipped truck freight collect.

ACCESSORY OFFER!

At the time you order any Meade Dobsonian, you can buy 2 additional multi-coated eyepieces, MA9mm and 12mm, *and* the Meade #637 6 x 30mm viewfinder with metal bracket for a **total of $49.95!** *Purchased separately, the 2 eyepieces and viewfinder sell for $125.85!* Offer valid until further notice.

AUTHORIZED U.S. MAIL-ORDER DEALERS

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

CALIFORNIA TELESCOPE COMPANY, Burbank, CA.
Orders & Information: 818-505-8424.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
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Orders & Information: 416-783-4140.

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Immediate delivery!

Computerize your Meade® Starfinder Telescope for only $295!

Spend your time **observing, not searching** for objects! **With the incredible Meade Magellan™ Telescope Computer System** attached to your Meade Starfinder Dobsonian or Equatorial, finding any of **12,218 celestial objects** is almost as easy as pointing the telescope.

- Don't spend $400, $500, or $600 for a computer system with fewer features! Designed and manufactured at the Meade Irvine facility, the Magellan I includes one of the largest object databases available, incorporates only premium-grade components, and sells for a low $295!

MEADE
ENTER
MODE
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NEXT
ON
MAGELLAN I
TELESCOPE COMPUTER SYSTEM
U.S.A

Actual Size: 4" x 5" x 1.25"

- **Easy to Use!** Just input the R.A. and Dec. of the object you wish to observe, or call up an object from Magellan's massive database. Magellan allows you to slew the telescope manually to the object and place it in the visual field, quickly and precisely.
- **Fast 2-Star Alignment:** Point the telescope at 2 bright stars selected from the star database, and the computer is aligned in *seconds*. No need to input time or date, latitude or longitude. Magellan's powerful microprocessor calculates telescope position in milliseconds and directs your movements of the telescope for fast, accurate object location.

Meade Magellan II Computer-Corrector for Starfinder Equatorials

Plug the Magellan II into the control panel of your Meade DC-powered Starfinder Equatorial *(right)* and you have *all the capabilities of the Magellan I (above)* ***plus*** a 4-speed, dual-axis, drive-corrector/microslewing system!

Includes: Magellan II hand controller *(right)* with 4 dual-axis speed rates (2x, 8x, 16x, 32x sidereal); high-resolution 4096-pulse encoders for both axes; electric Declination control system; 12,218-object computer database; 2-star alignment; RS-232 serial interface. (For Meade *DC-powered* Starfinder Equatorials, only.)

#2018: for Starfinder Equatorial
6", 8", or 10" . . . . $495.
#2019: for Starfinder Equatorial 16" . . . 595.

Prices plus $20 packing & shipping in the 48 states.

INDER
UTERS

■ **High-Resolution 4096-pulse Encoders:** Each Magellan system includes two premium-grade, high-resolution encoders. Encoder precision is 5.3 arc minutes.

■ **Large 32-Character LCD Red-Backlighted Display:** The same LCD display included with the Meade LX200 hand controller. Includes variable illumination from dim to bright.

■ **12,218-Object Database:** A database that includes an amazing array of objects:

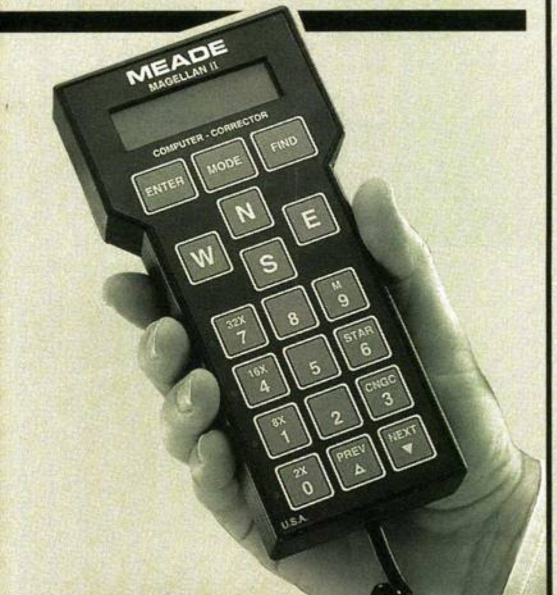
7,840	NGC *objects; the complete NGC catalog*
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

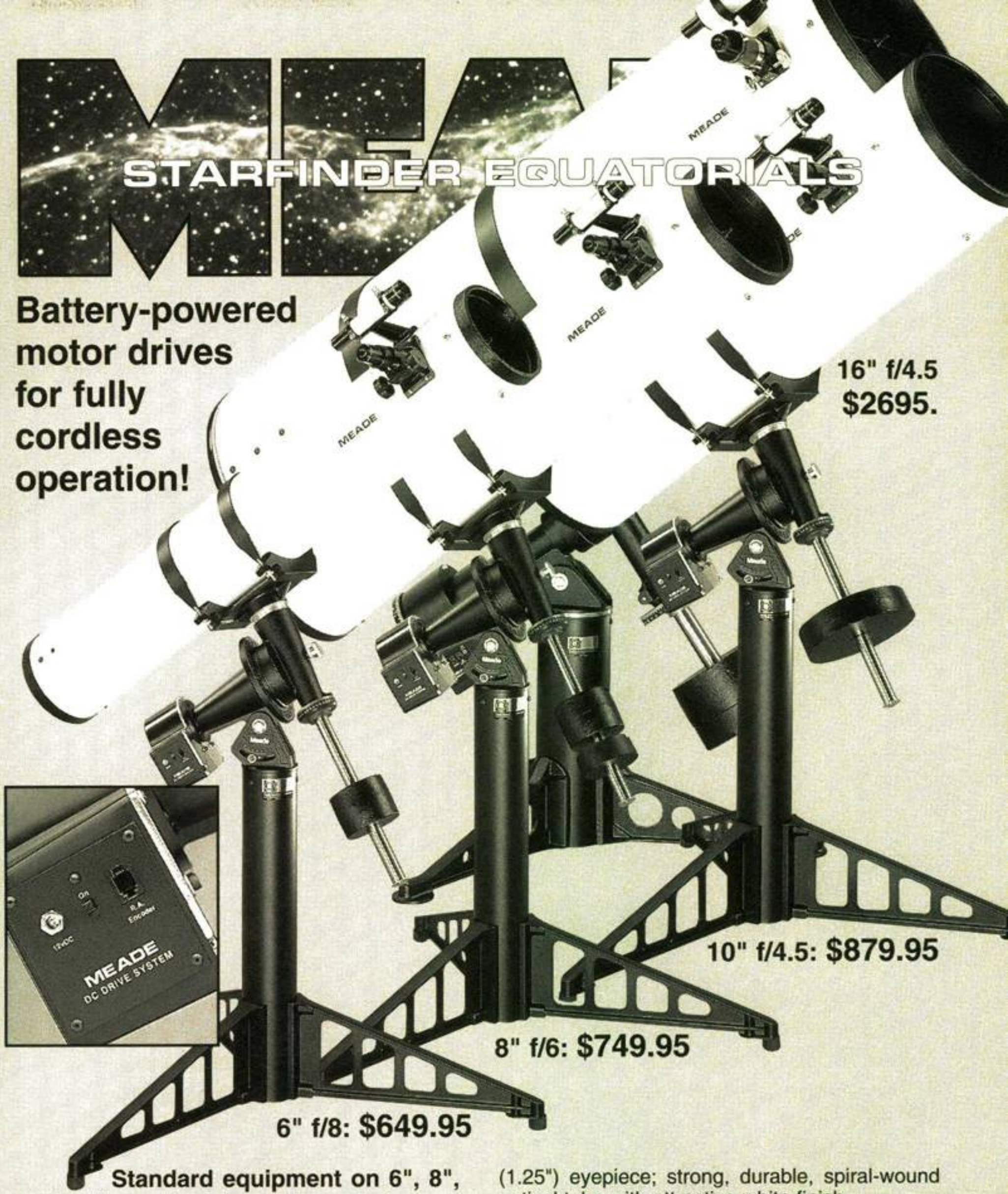
■ **Supplied Complete!** With other computers you pay *once* for the basic controller and then pay *again* for the "Encoder Installation Package." Meade Magellan Systems are supplied **complete** with: controller/display unit (4" x 5" x 1.25"); encoders for both telescope axes; RS-232 serial interface; bracket for convenient placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan is ready to use. First-time installation is quick and simple.

Meade Magellan I Telescope Computer Systems

#2010:	**for Meade Starfinder Dobsonian 6", 8", 10", 12.5", or 16"**	**$295.**
#2011:	**for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10"**	**295.**
#2012:	**for Meade (DC-powered) Starfinder Equatorial 16**	**295.**

All prices plus $15 packing & shipping in the 48 states. Prices shown are suggested U.S. national mail-order retail prices. For additional information on Meade Magellan systems, send for your free copy of the 94-page **Meade 1996 General Catalog.**





Standard equipment on 6", 8", and 10" equatorial models includes:

■ **Superb Optical System:** Includes hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

■ **Precision Equatorial Mount:** Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

■ **Battery-Powered Cordless Drive System!** Provides fully automatic tracking of celestial objects. Operates for more than 50 hours from 6 (user-supplied) AA-size batteries inserted through the drive cover. Control panel *(see inset photo, above)* also permits powering of telescope from 12v. auto cigarette lighter plug, using optional 25' cord.

■ **Accessories and Components:** Rack-and-pinion focuser (1.25") with 2.6" travel; #637 6 x 30mm viewfinder; multi-coated MA25mm (1.25") eyepiece; strong, durable, spiral-wound optical tube with attractive white finish.

■ **Starfinder Equatorial 16:** Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6"-dia. pier, 6 x AA-size battery-powered worm gear drive, 8 x 50mm viewfinder, #682 giant (2" & 1.25") rack-and-pinion focuser.

Packing and UPS Shipping Charges to any address in the 48 states: 6"–$65; 8"–$75; 10"– $90. 16"–$55 packing, shipped truck freight collect.

To Order: Contact your authorized Meade Advanced Products Dealer. All prices shown are suggested USA mail-order retail prices.

Free 94-page Meade 1996 General Catalog is available from your authorized Meade dealer or directly from Meade Instruments.

ACCESSORY OFFER!

At the time you order any Meade Starfinder Equatorial Telescope, you can buy 2 additional multi-coated eyepieces, MA9mm and 12mm, for a **total of $29.95!** *Purchased separately, the 2 eyepieces sell for $75.90!* Offer valid until further notice.

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FAX: (714) 756-1450

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Meade Pictor 1616XT images by Jack Newton: clockwise from upper left—Horsehead Nebula; M42; M51; M27.

MEADE

PICTOR™ SERIES CCD AUTOGUIDER/IMAGERS

Meade CCD imagers yield incredibly detailed images of the Moon, planets, or deep-space objects on the display screen of your personal computer. Place a Meade Pictor CCD imager in the eyepiece-holder of your telescope, connect the imager to your PC, *and in minutes you're imaging any object in the sky with an astonishing level of visible detail.* For complete details send $3.00 for the Meade 1996 General Catalog.

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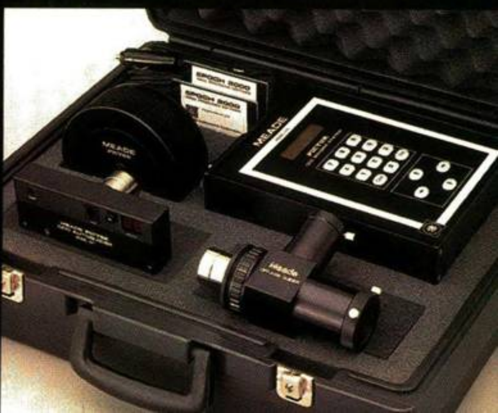
CCD imaging is **automatic** with a Meade Pictor Imager. And, for a limited time, when you purchase the Pictor 416XT at $2495 or the Pictor 1616XT at $6495, we'll pack it with the $800 Meade CCD Equipment System *(below)* **at no additional charge.** Use the Pictor 201XT and CCD Off-Axis Guider *(above)* to autoguide your Pictor 416XT or 1616XT—or your 35mm camera during astrophotography. No other autoguider/imager system is so flexible and so easy to use.



MEADE

EYEPIECES AND ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (3.45)
32mm (52°); **40mm** (44°)	each:	**99.95** (3.79)
56mm (52°; 2")		**199.95** (5.48)

Series 4000™ Ultra Wide Angle 84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (3.94); **6.7mm: 199.95** (3.94); **8.8mm** (1.25"/2"): **239.95** (5.87); **14mm** (1.25"/2"): **299.95** (6.28)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5° at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (3.60)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (3.45)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited *focus range. Maintains the high* image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (3.45)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (3.45)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

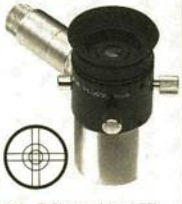
#929 or **#930,** each: **$99.95** (5.87)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.45)

World's Most Advanced Illuminated Reticle Eyepiece



Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (3.45)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (3.45)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

each **$14.95** (2.29)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (2.98)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (2.98)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (2.98)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.29)

#905 Variable Polarizer (1.25")

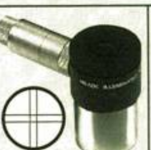
For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (4.27)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (3.45)

MA12mm Illuminated Reticle Eyepiece



Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. 1.25" **Batteries included.** **$99.95** (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (3.45)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": **$27.95**; 1.25": **$29.95** (2.98)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (2.98)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (2.98)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (2.98)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (4.27)

Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (3.94); **18mm: 149.95** (3.94); **24.5mm: 179.95** (4.68); **32mm** (2"): **239.95** (5.87); **40mm** (2"): **299.95** (6.28)

Series 3000™ Plössls
50° field; multi-coated

The very latest in eyepieces from Meade optical designers, new Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Available in a wide range of focal lengths from 5mm through 25mm. All five eyepieces are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. Manufactured exclusively for Meade Instruments by one of Japan's leading lensmakers, Series 3000 Plössls produce fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)
5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.45)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (3.45)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (3.85)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (3.94)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (3.45)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (3.85)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (3.94)

Series 3000™ Plössl 40mm 44°

An excellent complement to the Series 3000 Plössls above, this all-new Plössl 40mm produces spectacular low-power, wide-field results with any telescope. Includes classical 4-element Plössl optics, **multi-coated.** Barrel dia. 1.25"; threaded for filters. Apparent field: 44°.

$79.95 (3.79)

HOW TO ORDER

- Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes.
- Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price.
- Meade accessories may be ordered from any Meade Advanced Products Dealer. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

CALIFORNIA TELESCOPE CO., Burbank, CA.
Orders & Information: 818-505-8424.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders: 800-621-2248; Info/IL: 312-332-2000.

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EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

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ASTRO LETTERS

Three Cheers for Two Planets

The article "Two New Solar Systems" by Robert Naeye (April 1996) was absolutely fantastic. I liked the way Naeye worked in other similar subjects that made understanding the significance of the current search clear. Three cheers for two planets! — *Wesley Thomas, Dallas, Texas*

Can astronomers really use the word "planets" to describe these new discoveries? Perhaps they should be using the word "satellites" until they find out more about the nature of these objects. — *Bruce W. Amlismeier, Chicago, Illinois*

The author states that astronomers know "virtually nothing about the new planets" but can tell us the temperature at the cloudtops of 70 Virginis B is about 85° C. How much credence can be placed on this number when in "Into the Maelstrom" by Robert Burnham we are told that "The Jupiter that the probe [Galileo] sampled on December 7, 1995, differed significantly from scientists' expectations. . . ."

How can we be so ardently certain about our hypotheses but so blatantly wrong with our facts? — *Jim Erjavec, Mason, Ohio, erjavecj@aol.com*

Heaven Revisited

I couldn't believe Henry Shuda's letter (Letters, May 1996) criticizing Jeff Kanipe's Forum article "The Relativity of Heaven." Come on, Mr. Shuda! Your letter seems to have more to do with the possibility that there may be a God than the "mysticism" that invaded the pages of the magazine. In my opinion ASTRONOMY magazine has no equal. But I would never expect it to be a source of religious doctrine.

Mr. Kanipe exactingly described what the Forum column is all about, and I agree with him. — *Christopher M. Anthony, Des Moines, Iowa*

I found it difficult to believe that such a subtle statement in Mr. Kanipe's article would stir up such a negative response. People have different ideas, and there's no need to put down the ideas of others just because they don't match your own. — *Jon Stamets, Lakewood, Pennsylvania*

The Ethics of Astro-Imaging

I mostly agree with Jason Ware's letter regarding manipulating astro images (April 1996). At what point have we gone too far with image manipulation? Once upon a time the editors at ASTRONOMY returned to me (and correctly so) some images I submitted that I had "doctored." My objective was not to outdo anyone, but to create the best images I could.

But with electronic image processing, it's easier than ever to make wholesale changes to astronomical images. Must we now adjust the color balance, density, and apply filters like edge sharpening to arrive at what we think is an optimum image? Compare any film-based images of the Eagle Nebula to the ones taken by the Hubble Space Telescope.At what point do images cease to be real? — *Mace Hooley, procolor@accesscom.net*

It's discouraging to see astrophotographers get so competitive that they try to belittle the work of other astrophotographers. — *John Chumack, Dayton, Ohio*

Going Off the Deep End

I began reading ASTRONOMY in 1993 and have enjoyed seeing the coverage of astronomical objects one can observe in a telescope. While many of the objects frequently mentioned are relatively bright and can be observed from sites near cities, I want to thank you for "A Window into the Deep" by Tom Johnston (April 1996). This article on the Hercules Cluster of galaxies is something I've waited a long time to read. Scopes in the 10-inch to 25-inch range show members of many other galaxy clusters on dark nights, like those in Pisces, Pegasus, Leo, Lynx, Gemini, Perseus and, of course, Virgo. Thanks for jumping into the deep end. — *Colin Butler, Fulton, New York*

Crystallized White Dwarfs

I thought the article "White Dwarfs Confront the Universe" by Ken Croswell (May 1996) was fascinating and informative. My curiosity was piqued not only by the techniques of dating the Milky Way with these stars but also with regard to the crystallization that occurs in them.

Why does this crystallization take place? Is it because temperature drops to a point where the gravity can compress the material into a solid? This material, mostly carbon and oxygen, would be extremely dense, as the article states. But I wonder what would happen if one transported some of it instantly to a low-gravity environment like Earth? — *Joseph P. Zumar, zumarjp@a1.jlc01.umc.dupont. com*

Ken Croswell responds: Crystallization occurs because the star cools. When the white dwarf falls to a temperature of about 7000 kelvins, the thermal energy becomes too small to oppose the electrostatic attraction of the ions in the dense material, and the star begins to freeze into a crystal lattice. By terrestrial standards, however, this material is still very hot. A white dwarf's intense gravity keeps this hot material compressed to enormous densities. If a ton of this material — a mere spoonful, that is — were transported instantly to Earth, it would explode violently and become a gas.

Remembering Ole Rømer

I must correct a statement in "The Dance of Jupiter's Moons," page 64, March 1996, which stated that Ole Rømer was Dutch. He was Danish, in fact. Not only did he time the speed of light, but invented the meridian circle, introduced the Gregorian calendar to Denmark and Norway, pioneered a standard system of weights and measures, and improved the water supply, street lighting, and refuse removal for the city of Copenhagen. — *Kenneth D. Frederiksen, Årslev, Denmark* ☐

ASTRONOMY welcomes feedback. Send your letters to ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187, or on the Internet you may use letters@astronomy.com. Letters may be edited for space and clarity.

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Recognized around the world for product quality and cutting-edge advances, Thousand Oaks Optical filters are the preferred choices of telescope retailers and used exclusively by NASA aboard the Space Shuttle. Other professional users include: ABC, CBS, NBC, CNN News, NOVA, The Discovery Channel, National Geographic, and most major universities and observatories. Thousand Oaks Optical is the largest manufacturer of solar filters. Tens of thousands are in use worldwide.

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NOTICE: Beware of a person claiming that he was once affiliated with Thousand Oaks Optical, and that his solar filters offer an Indentical View. Thousand Oaks Optical hereby disavows responsibility for the safety and quality of filters sold by this former employee whose responsibilities were limited to cleaning and assembly.

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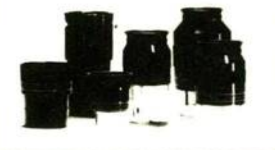

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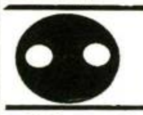

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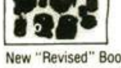

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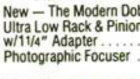

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ASTRO FORUM

A Labor of Love and Adventure

by Patti A. Kurtz

The year is 1957.

A 13-year-old boy excitedly sets up his brand new telescope — a 3-inch Skyscope reflector — on the third floor balcony of his Chicago apartment. Pointing the shiny black instrument at the bright star Arcturus and then Jupiter, he gasps in amazement. He has been given the universe with a single $29 gift! He now has a way to escape the ghetto through the stars.

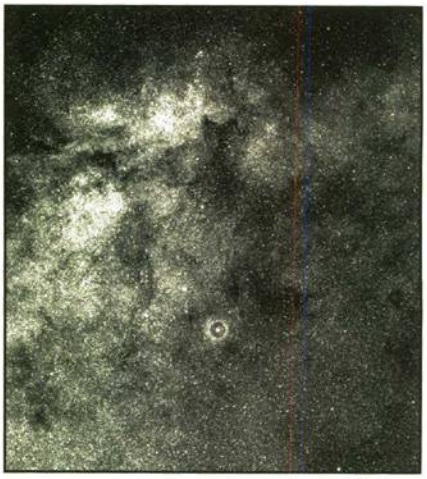
Who would have thought, in 1957, that this gift would lead to a lifetime of labor, love, and adventure for noted observer and astrophotographer Gary Emerson? Thirty-nine years later he still thrills to the views he receives from the skies.

Who would have thought, in 1957, that this patient yet relentless Colorado amateur would snatch minor planet 1995 SL5 from the jaws of obscurity on September 29, 1995, as it hurtled through space?

Emerson found the 17.4-magnitude asteroid, his first such discovery, while imaging another asteroid. "I assumed it was a known asteroid, but logged onto IAU's computer to make sure. When it wasn't there, I started getting excited."

Emerson's inspiration was his seventh grade teacher, Clarence Collins, who, like many dedicated educators, went out of his way to get students interested in a better way of life. For Emerson, astronomy started as an escape that led to pure enjoyment.

Although he's worked in the field on and off since 1966 — beginning at NASA doing lunar observing and running through to the present as a CCD test engineer for Ball Corporation in Boulder, Colorado — he considers astronomy a serious hobby. Despite his technical involvement, Emerson is adamant about not losing what he calls the "wow" factor.


Gary Emerson

A view near the galactic center

"Do astronomy for the enjoyment of the hobby or the love of the science," he advises. "So many people get caught up in the competitiveness of instruments and the mechanics of it. Don't lose sight of what it's all about for you."

For Emerson, it's about being a part of something bigger than we are, not what you're looking at the sky with. "On a dark summer night, lie on your back with a pair of binoculars aimed at the Milky Way. For sheer enjoyment, that's hard to beat."

Even Emerson's choice of home, overlooking Colorado's largest state park, was astronomically driven. He named his observatory the E. E. Barnard Observatory because he wanted to keep Barnard's name alive. Many feel that Edward Emerson Barnard was the foremost American observational astronomer of his time. He was well known for discovering comets and nebulae, Barnard's star, and the fifth moon of Jupiter, as well as his frequent and consistent utilization of photography in astronomy.

"He was a pioneer in astronomical photography," says Emerson. "Barnard was one of the first to use photography as a tool for exploring the Milky Way." One of Emerson's projects involves re-imaging all the objects in Barnard's *Atlas of Selected Regions of the Milky Way* for comparison purposes, some 90 years later. (See "E. E. Barnard's Magnificent Milky Way," June 1996.)

So, what's an average observing session like with Emerson? He starts by viewing two or three variable stars and then a couple of faint comets, using finder charts he made during the day. Next he takes a series of images of some nebulae or galaxies that he doesn't already have. It's getting cold, so around 1 a.m. he warms up with something hot to drink, then continues imaging.

"My favorite time is right before dawn when I imagine I'm the only one awake. I own the world and it's really peaceful."

Emerson's many travels often revolve around astronomy. He's followed solar eclipses to Mexico and East Africa. He's even been to Antarctica, where he delivered a 12-inch telescope used for site evaluation.

The many images he's made, however, mark Emerson's contribution to astronomy. He is known far and wide as an astrophotographer (both film and CCD), and people the world over call him for help in confirming supernovae, comets, and asteroids.

As if he needed more to keep him occupied, Emerson took on the Distant Comet Monitoring Project with John Brandt of the University of Colorado. He says distant comets are *often ignored* and he is organizing a team to monitor their activity. If you're interested in participating, contact Emerson at 34226 Gap Road, Golden, CO 80403.

Emerson's passion for astronomy goes deeper than the technical side, however. On a clear, dark night, he often enjoys his favorite object — M13, the great globular star cluster in Hercules. With a long focal length Cassegrain on a good night, Emerson says, "It appears almost three dimensional and I feel I can really grasp it. It's such a gorgeous object."

On frigid mornings, you can bet Emerson is recording the universe for the sake of knowledge and for simple appreciation. Which of these two is more important? For Emerson, the best answer is probably both. □

Patti A. Kurtz is assistant editor of Astronomy magazine.

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Closing in on the Hubble Constant

Two teams of astronomers observing with the Hubble Space Telescope appear to be closing in on one of the most crucial parameters in astronomy: the expansion rate of the universe, also known as the Hubble constant.

One team, led by Wendy Freedman of the Carnegie Observatories, finds a Hubble constant between 68 and 78 kilometers per second per megaparsec (one megaparsec equals 3.26 million light-years). The other group, led by Allan Sandage, also of the Carnegie Observatories, finds a Hubble constant between 53 and 61.

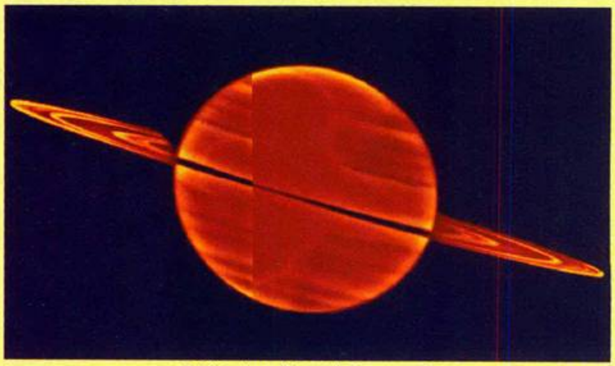
Freedman's group used five techniques to derive their value. The primary technique involved a type of pulsating star known as a Cepheid variable. They used Cepheids to determine distances to 12 nearby galaxies. They next used four secondary methods to calibrate distances to galaxies so far away that their Cepheids are not visible (see "Milestone in Fornax," October 1995). One of the methods uses a type of exploding star known as a type Ia supernova.

Sandage's team used Cepheids to derive distances to five galaxies. Once they had these distances, they used type Ia supernovae to determine distances to galaxies much farther away.

Although the groups find different expansion rates, these differences have narrowed significantly. Freedman's team previously used the space telescope to get a Hubble constant of about 80 based on only one galaxy, M100 in the Virgo Cluster. And Sandage's team earlier derived a Hubble constant of 52. Prior to the launch of Hubble, various teams of astronomers measured Hubble constants ranging between 40 and 100.

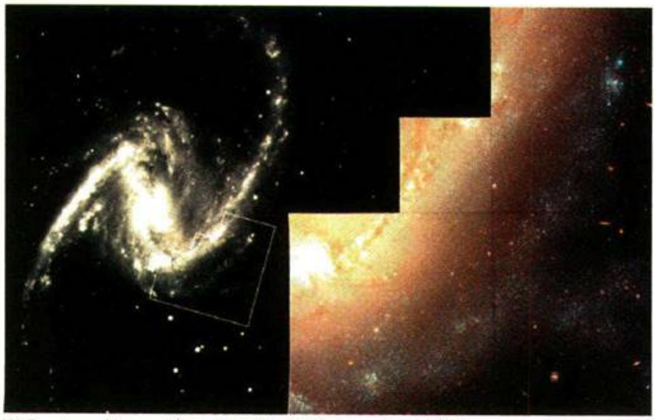
The Freedman result implies a universe between 9 and 12 billion years old, slightly younger than the estimated age of the oldest stars in the universe. The Sandage result implies a universe between 11 and 15 billion years old, barely old enough to accommodate the oldest stars.

Freedman emphasizes that her group is midway through a 3-year program. The team's goal is to nail down the Hubble constant to within 10%. "We're encouraged that within the next couple of years we'll be able to understand the remaining differences and solve one of the problems that's been outstanding in observational astronomy for almost seven decades," she says.



P. Nicholson (Cornell), S. Larson (U. of Arizona), and NASA

SOMETHING LOOKS A LITTLE STRANGE in this Hubble Space Telescope image of Saturn taken on November 21, 1995, when the Sun had just passed south of the ring plane but Earth still lay 2.7° north of it. Working from the outer edge toward Saturn, the three bright areas are the F ring, Cassini's division, and the C ring. These normally faint regions appear bright because the particles within them are the right size to backscatter sunlight efficiently. The F ring disappears part way around the west (right) side, which leads astronomers to speculate that it is slightly warped. The normally bright A and B rings are faintly visible because they reflect sunlight from Saturn's disk.



W. Freedman (Carnegie Obs.), HST Key Project team, and NASA

ASTRONOMERS OBSERVED 50 Cepheid variable stars in this barred spiral galaxy, NGC 1365 in the Fornax Cluster, helping to determine that it is roughly 60 million-light years away.

A. Sandage (Carnegie Obs.), et al., and NASA

NGC 4639 in the Virgo Cluster is roughly 78 million light-years away, according to observations by a team led by Allan Sandage.

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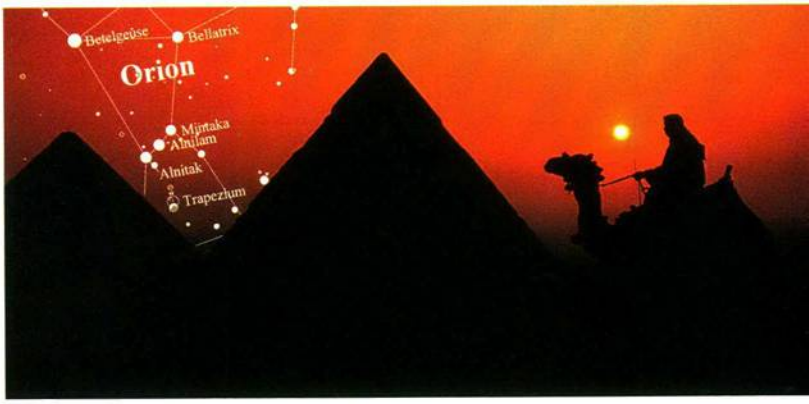
CCD Astronomy: M27, as located, imaged and processed using TheSky Astronomy Software.



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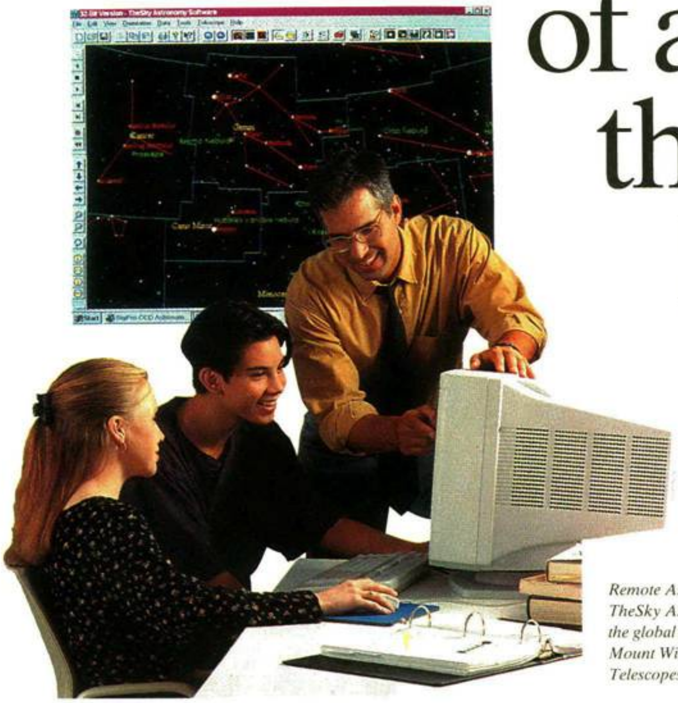

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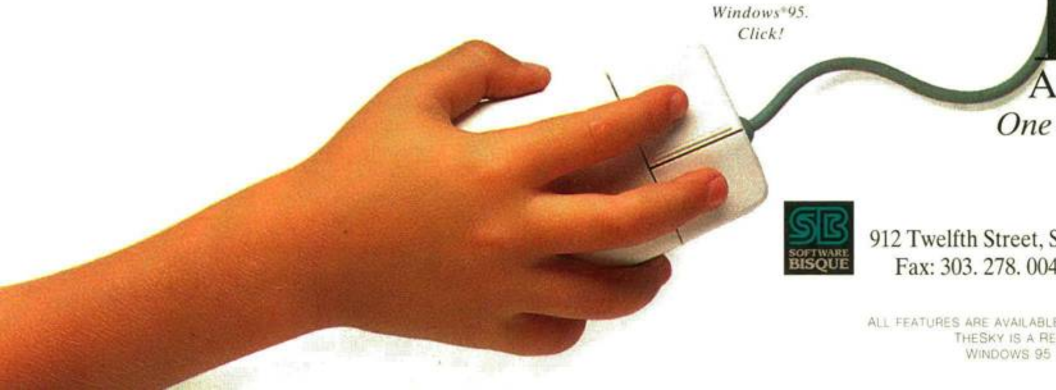

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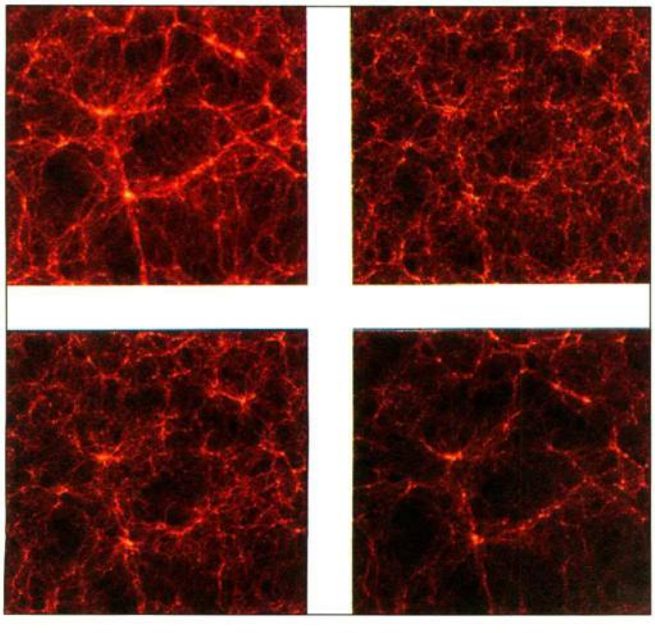
Computer Cosmology

Will the universe expand forever or collapse back upon itself? How much matter is in the universe? How did galaxy superclusters come together? A consortium of European and Canadian astronomers found possible answers by watching the entire 10 to 15 billion-year history of the universe unfold inside a computer.

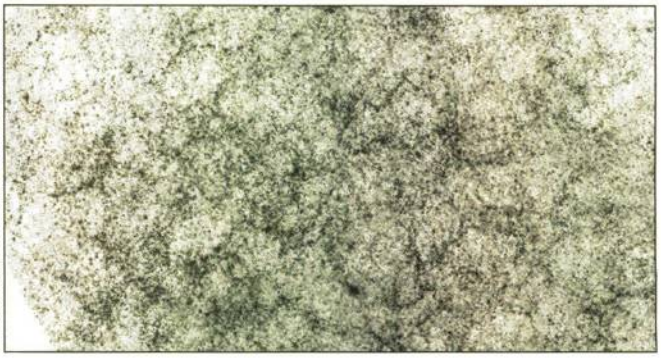
The simulations, the most sophisticated ever, reveal how the universe might have evolved from an epoch just 300,000 years after the big bang to the present. The consortium, led by Carlos Frenk of the University of Durham in England, plugged four different sets of parameters into two Cray supercomputers. Each simulation assumes different conditions in the early universe. The starting point for each is the origin of the cosmic microwave background, the faint radio echo of the big bang discovered in 1964. The simulations allow subtle ripples in the microwave background — detected by the COBE satellite in 1992 — to grow and evolve in one-million-year increments.

One of the four trials produced a universe very similar to the real thing; the ripples grew into long filamentary structures that look like galaxy superclusters surrounding enormous voids of virtual nothingness. The winner of the cosmic sweepstakes was a universe containing only 30 percent of the amount of matter needed to bring the expansion of the universe to a halt. Surprisingly, the successful model also included a cosmological constant, a term representing a repulsive force that Einstein included in his general theory of relativity but later discarded.

Models assuming higher and lower densities of matter didn't fare very well, producing either too much structure or not enough. Although the simulations represent a giant leap forward for cosmology, team member Hugh Couchman of the University of Western Ontario cautions, "These are only simulations, and we are still quite a way from forming what you would think of as a galaxy."



Hugh Couchman (Univ. of Western Ontario)



M. Seldner, B. Siebers, E. Groth, and P. Peebles

THE WINNER. Four recent computer simulations wind up with only one universe (upper left) that looks like the one we live in (far right).

A Nearby Extrasolar Planet?

One of the closest stars to Earth might be orbited by a Jupiter-mass planet. The star, 7.5-magnitude Lalande 21185 in Ursa Major, is an M2 red dwarf only 8.25 light-years from Earth. Only the Alpha Centauri triple star system, Barnard's star, and Wolf 359 lie closer.

Because of Lalande 21185's proximity, it races across the sky at 4.78 arcseconds per year — only a handful of stars move faster. Observations of the star dating back 50 years indicate that it has speeded up and slowed down during this period, as if a low-mass orbiting companion was pulling it along and then holding it back. Until recently, however, the observations weren't precise enough to tell for sure if the star was actually changing speeds.

But recent, extremely high-precision observations by George Gatewood and colleagues at the Allegheny Observatory in Pittsburgh, Pennsylvania, strongly suggest that the star's velocity is indeed changing over time. "I'm pretty sure there must be something causing a significant change in velocity," says Gatewood. Previous observations have ruled out a second star in orbit around Lalande 21185.

Gatewood says if the acceleration is being caused by a planet, the planet has a mass between one-half and two Jupiters, and it orbits Lalande 21185 every 35 to 50 years, putting it at about the same distance from the star that Saturn is from the Sun. Gatewood announced his findings at the June 1996 meeting of the American Astronomical Society in Madison, Wisconsin.

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M27. *Tricolor CCD image taken with a Celestron C-8 at f/6.3 with an ST-7 CCD imaging camera and CFW-8 Color Filter wheel. Courtesy Benoit Schillings, Los Altos, California.*

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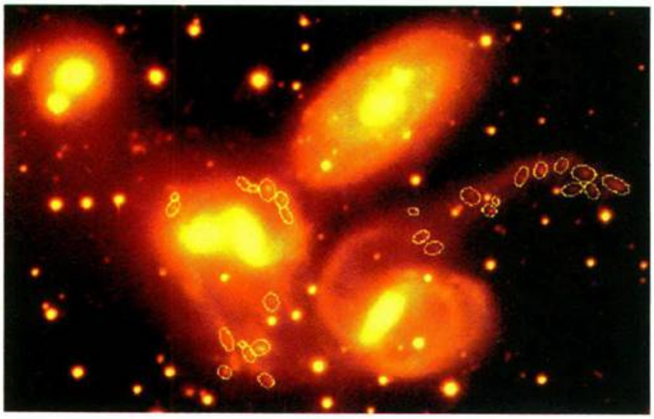
The Birth of Dwarfs

A study in the May 1 *Astrophysical Journal* concludes that as many as one-half of all dwarf galaxies — which themselves make up the vast majority of galaxies in the universe — formed in titanic collisions between their larger brethren. Astronomers previously envisioned dwarf galaxies as forming by the gravitational accumulation of matter. Dwarf galaxies typically contain 100 million times the mass of the Sun, whereas large galaxies like the Milky Way can be thousands of times more massive.

Using the 60-inch telescope on Palomar Mountain, a team led by Sally Hunsberger of Penn State University studied 42 groups of densely packed galaxies. Galaxies frequently collide inside these compact groups. When two large galaxies pass close to each other, tidal interactions draw long tails of gas from each galaxy.

"Initially, we just wanted to see how many dwarf galaxies we could find in compact groups, but then we noticed a lot of interesting tidal debris in seven of them," says team member Jane Charlton of Penn State. "We took a closer look at the tidal features and detected 47 areas that appear to be dwarf galaxies."

Most dwarfs in the universe aren't found this close to larger galaxies. But the group speculates that many dwarfs form inside tidal tails, only to be flung away from their birthplace by the gravity of other galaxies.



Jane Charlton (Penn State Univ.)

DWARF GALAXIES (yellow ovals) apparently form inside tidal tails that are the result of colliding galaxies.

In another study relating to tidal tails, University of California at Santa Cruz astronomers used computer simulations to determine that the longest tidal tails result from colliding galaxies with small quantities of dark matter.

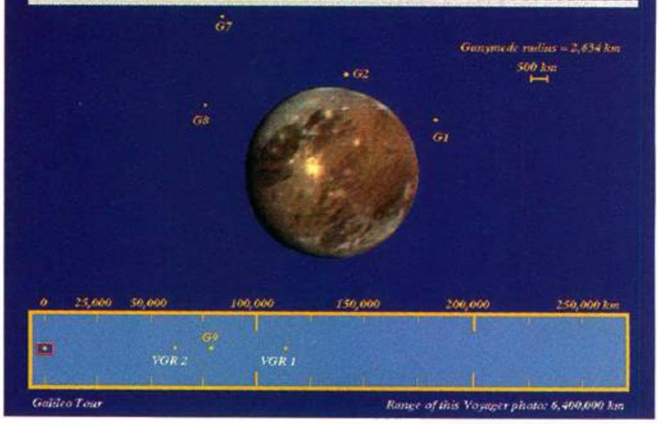
Getting to Know Jupiter & Company

As you read these words, Galileo is poised to take the closest look yet at a jovian moon, Ganymede, on June 27. When the spacecraft comes to within 980 km of the planet-sized satellite, on-board cameras will glean details as small as 250 meters across. The spacecraft's encounter allows the first photo survey of a Galilean moon since Voyager 2 flew past Jupiter in July 1979.

Meanwhile, project scientists continue to announce findings from the orbiter's December 7 flyby of Io and the atmospheric probe's entry into Jupiter's clouds. A more detailed analysis of probe data shows that 24% of Jupiter's atmosphere is helium, up from the 14% announced last January (see "Into the Maelstrom," April 1996). This new estimate closely matches the relative helium abundance of the Sun and tells scientists that Jupiter's composition has not changed much over billions of years. It also hints that the planet may have a bigger rocky core than expected.

The probe revealed still more about the planet's atmosphere. Fast 640 kph winds (up from January's announced 530 kph) imply that heat from deep inside the planet, rather than sunlight, drives Jupiter's violent weather. The presence of heavy elements like carbon, nitrogen, and sulfur reveals that meteorites played an important role in Jupiter's evolutionary history. The probe also tells of a Jupiter drier than what analysis of Voyager data and studies of the Sun's water content had predicted.

While Galileo's probe descended into Jupiter's clouds, its mother ship, the orbiter, skimmed within 900 km of Io. Subtle deviations in the orbiter's flight path betrayed that the 3,630-km-wide satellite has an iron core roughly 1,800 km across. Astronomers also noted a 30% drop in the strength of Jupiter's powerful magnetic field as Galileo approached Io. This "magnetic hole" suggests that Io might sport its own magnetic field. Confirmation should come when data from other space experiments gets radioed to Earth.



JPL

GALILEO'S EXPLORATION OF GANYMEDE begins with a 980-km flyby on June 27. Encounters over the next 11 months will occur during Galileo's second, seventh, and eighth orbit of Jupiter, and will close to within 255 km of Ganymede's surface. This is over 230 times closer than Voyager 2's pass in 1979.

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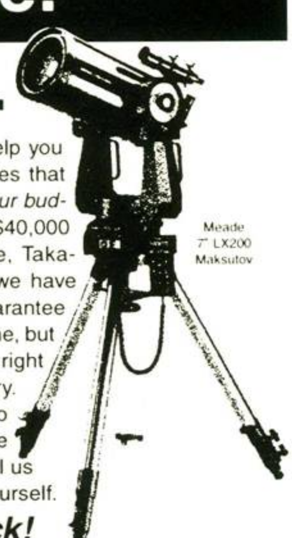
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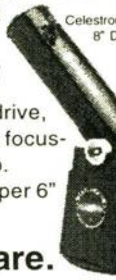
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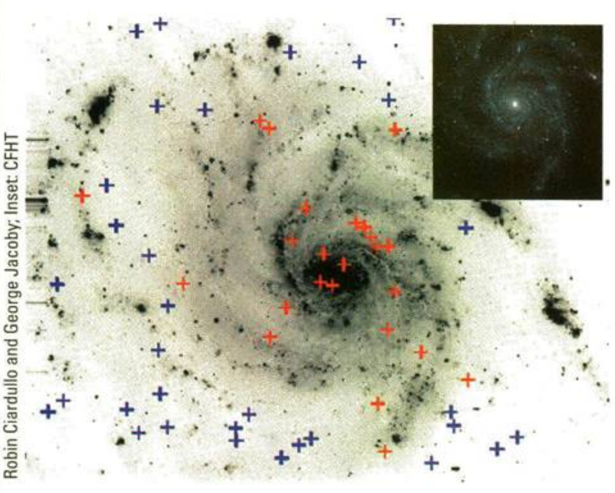
Are Quasars Formed in Collisions?

A new hypothesis challenges the conventional view that quasars result when gas accretes onto massive black holes at the centers of galaxies.

In the April 1, 1996, *Astrophysical Journal Letters*, Masataka Fukugita (Institute for Advanced Study and Kyoto University) and Edwin L. Turner (Princeton University Observatory) propose that the universe contains a large number of supermassive black holes that exist independent of galaxies. The researchers argue that quasars occur when these black holes collide with galaxies or gas clouds in the intergalactic medium.

Fukugita and Turner base their hypothesis on recent Hubble observations that show relatively nearby quasars exist in a wide array of different environments and few lie at the centers of normal galaxies. The model may also explain why quasars are so rare in the nearby universe: As scientists look deeper into space, they see further back in time, to an era when the universe was more compact and thus collisions more common.



Robin Ciardullo and George Jacoby; Inset: CFHT

HOW FAR TO M101? Astronomers studying planetary nebulae in this giant spiral galaxy in Ursa Major have determined that it lies 24 million light-years from Earth, a result similar to that obtained by HST observations of Cepheids in the galaxy.

Using the 4-meter telescope on Kitt Peak in Arizona, astronomers John Feldmeier and Robin Ciardullo of Penn State University and George Jacoby of Kitt Peak National Observatory identified 65 planetary nebulae candidates (indicated by the blue and red crosses) in M101, showing for the first time that this technique works in spirals with loosely wound arms. Because the brightest planetaries in most galaxies have approximately the same intrinsic luminosity, they can be used as "standard candles" for measuring distances. And because they are brighter than Cepheids, they can be used out to greater distances.

EVENT HORIZON

Planets, Planets, and More Planets

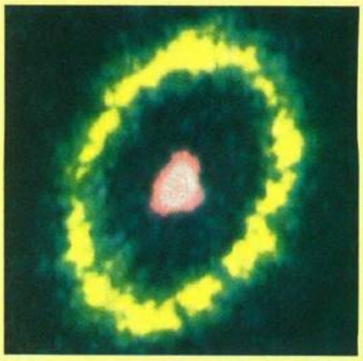
A group led by Harvard astronomer David Latham has recently discovered possible substellar companions orbiting the stars HD 149913 and HD 29587. In 1989 Latham and colleagues discovered an object orbiting the star HD 114762 that appeared to have a minimum mass of about 11 Jupiters. Planet hunters Geoff Marcy and Paul Butler have lowered HD 114762's companion's minimum mass to only 10 Jupiters, boosting the notion that it might be a giant planet.

Plucky Buckyballs

Scientists from the University of Rochester and the Scripps Institute of Oceanography found buckyballs inside a huge impact crater near Sudbury, Ontario. Buckyballs, the third-known pure form of carbon (the others being graphite and diamond), contain 60 or 70 carbon atoms arranged in a soccer-ball shape. The scientists think the buckyballs fell to Earth inside a comet or meteorite nearly 2 billion years ago and that the impacting body came from beyond the solar system. The discovery supports the theory that meteors and comets delivered organic materials to Earth.

No Pulsar Yet

Astronomers continue to look for a pulsar at the heart of Supernova 1987A. Recent observations made with the 3.9-meter Anglo-Australian Telescope didn't see one down to magnitude 24.6. The pulsar could either be fainter than normal, or the supernova's debris might still be obscuring it. Alternatively, the pulsar might have collapsed into a black hole.



STScI

Supernova 1987A (pink blob) has yet to show its pulsar.

Hard-Working Astronomers

After receiving the security blanket of tenure, do most astronomers become couch potatoes? The answer is no, according to a paper in the April 1996 *Publications of the Astronomical Society of the Pacific*. The study found that 48% of astronomers published more research papers per year after receiving tenure than before, and that 33% published between half and the same number of papers per year after receiving tenure than before. Only 19% published less than half as many papers per year, and some of those astronomers were engaged in administration.

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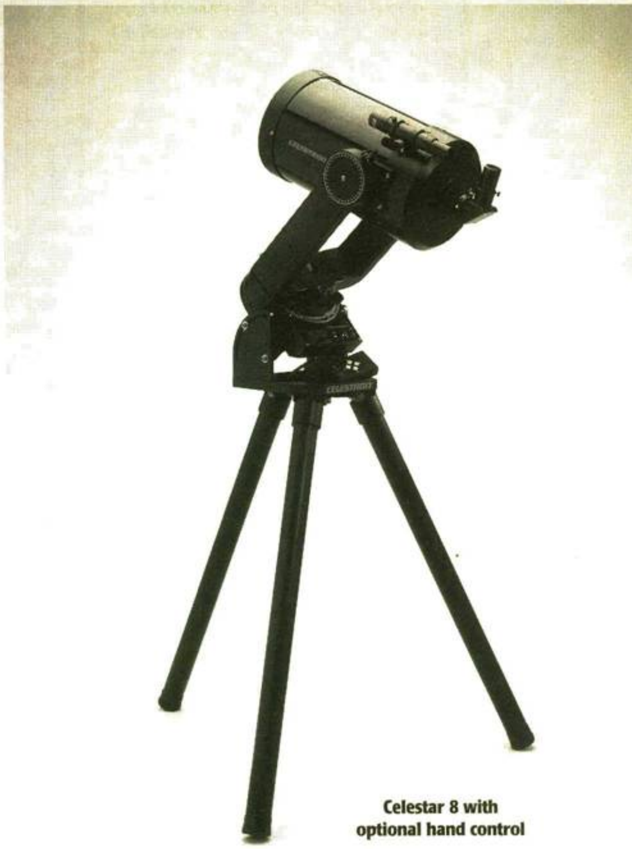

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Peach State Star Gaze Delights Georgians

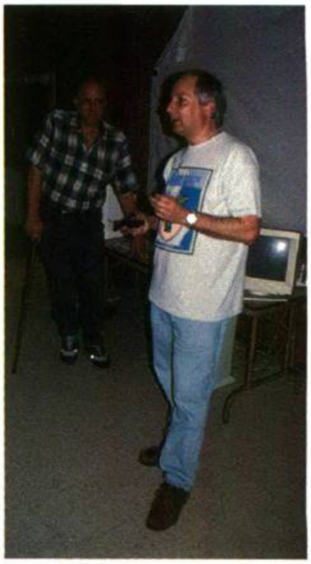
The 1996 Peach State Star Gaze enchanted 110 amateur astronomers from the Atlanta area and beyond with observing, talks, and workshops. The event, held at Indian Springs State Park near Jackson, Georgia, took place from April 18–21. "We are the largest astronomy gathering in Georgia," says organizer Ken Poshedly, "and we would like to see the event grow in future years."

The weather was hit and miss, with portions of nights featuring clear, dark skies and others offering only rain. Nonetheless, the few dozen telescopes set up on the camping ground provided views of Venus, Mercury, the Moon, and myriad galaxies and clusters. As the nights matured, the focus shifted to planetary observing, as many members of the Association of Lunar and Planetary Observers (ALPO) were on hand.

Talks similarly emphasized ALPO activities. James K. Rouse described how to photograph sunsets, as well as displaying some outstanding shots of Comet Hyakutake (1996B2). Julius Benton outlined the various ALPO observing programs focusing on the Moon, describing the need for "more observers following the Moon on a regular basis with a small telescope." Benton described the various ALPO lunar activities, including the lunar dome survey, observing bright and banded craters, selected areas, Lunar Transient Phenomena, and dark-haloed craters. Paul Traufler described his observations of artificial satellites. And Dawn Jenkins outlined how one can go about observing the sky with binoculars, an activity she's championed since 1983.

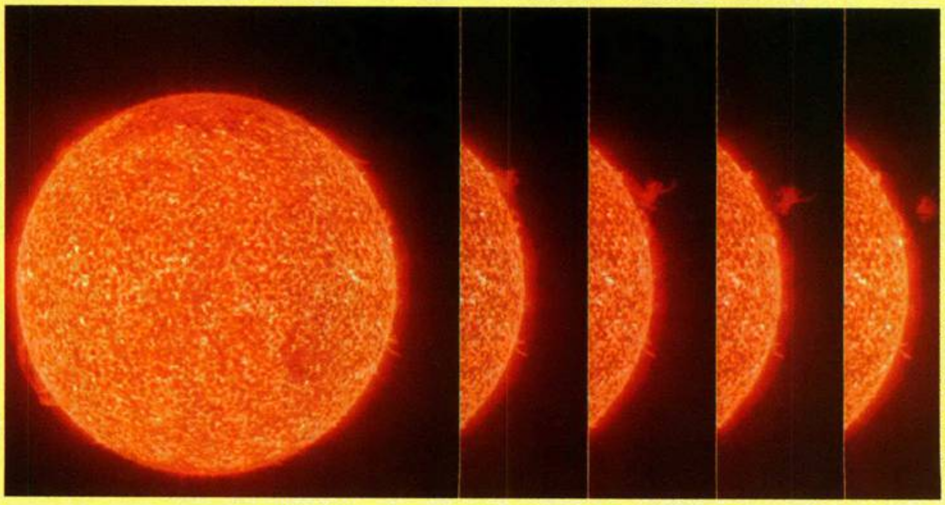
The final talk featured Don Parker, the well-known Florida CCD imager of planets, who regaled the crowd with his activities built around planetary CCD imaging. Others in the audience including Jerry Armstrong of the Atlanta Astronomy Club featured a dazzling array of CCD images of the Moon, deep-sky objects, and Comet Hyakutake. With the broad overall focus on ALPO activities, several members invited those interested in observing the Moon and planets to contact ALPO's membership secretary, Harry Jamieson (Box 16882, Memphis, TN 38186) for information on how to join the organization.

Workshops highlighted star-hopping (Art Russell), sketching at the eyepiece (Rich Jakiel), and mirror washing (Alex Langoussis). Organizer Poshedly looks forward to a vibrant event next year. Those interested in the plans may contact Poshedly at 3440 Everson Bay Court, Snellville, GA 30278. His e-mail address is 102745.313@compuserve.com.



ASTRONOMY: David J. Eicher

PEACH STATE ORGANIZER KEN POSHEDLY instructs the crowd about the night's activities as guest speaker Don Parker looks on.



NASA/Goddard Space Flight Center

A BLOB OF HOT, IONIZED GAS erupts from the Sun over a 5-hour interval on February 11, 1996. The joint NASA/European Space Agency Solar and Heliospheric Observatory (SOHO) snapped this ultraviolet image sequence, which shows the blob at the upper right of each image. The Sun is spitting out the blob at a speed of 24,000 kilometers per hour. The blob itself is about 35,000° Celsius and is 80,000 kilometers long, six times Earth's diameter. Such eruptions occur when the ionized gas breaks out of the low-level magnetic field that confines it to the solar atmosphere. The blob eventually dissipated as it traversed interplanetary space. To see more SOHO images, check out the following Web site: http://sohowww.nascom.nasa.gov/.

It found C/1996 B2, Comet Hyakutake

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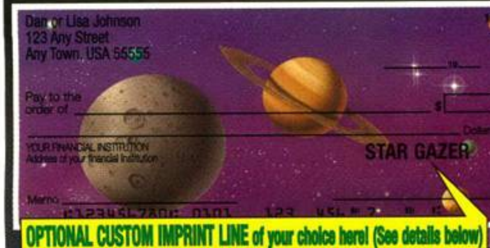

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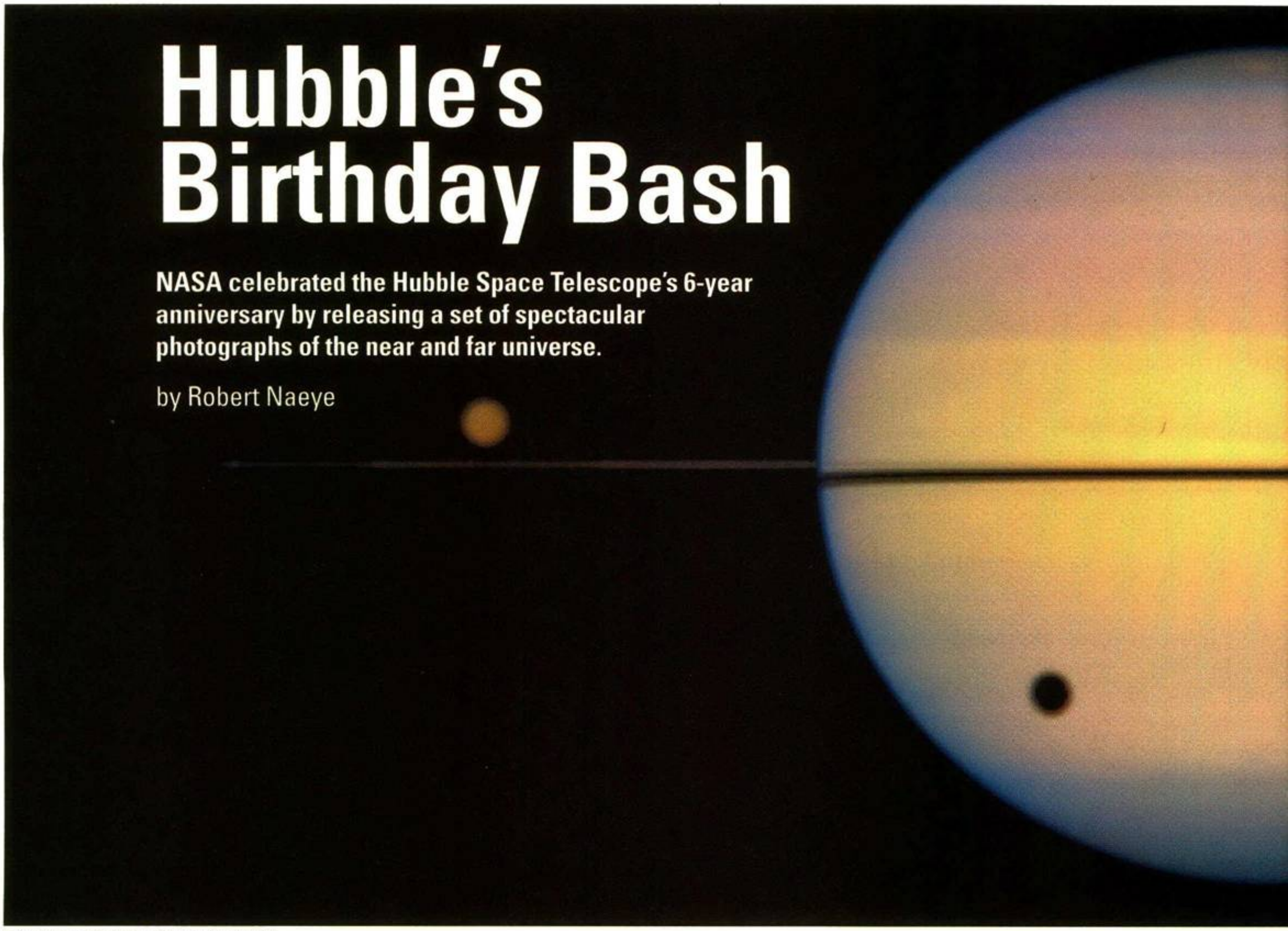
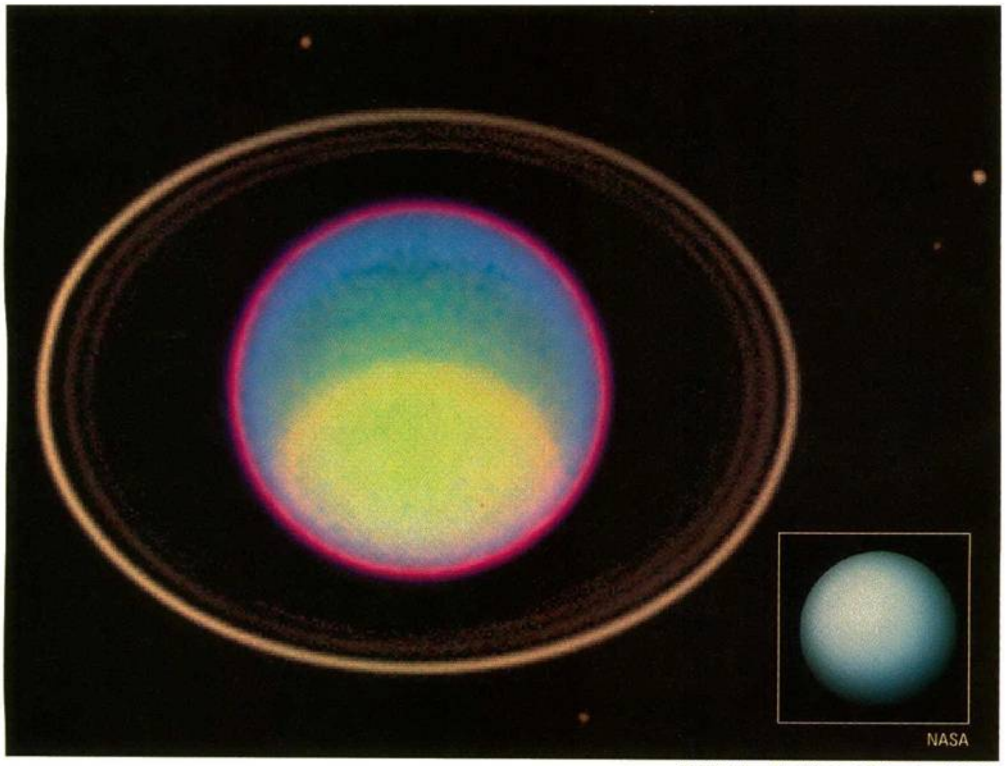
Hubble's Birthday Bash

NASA celebrated the Hubble Space Telescope's 6-year anniversary by releasing a set of spectacular photographs of the near and far universe.

by Robert Naeye



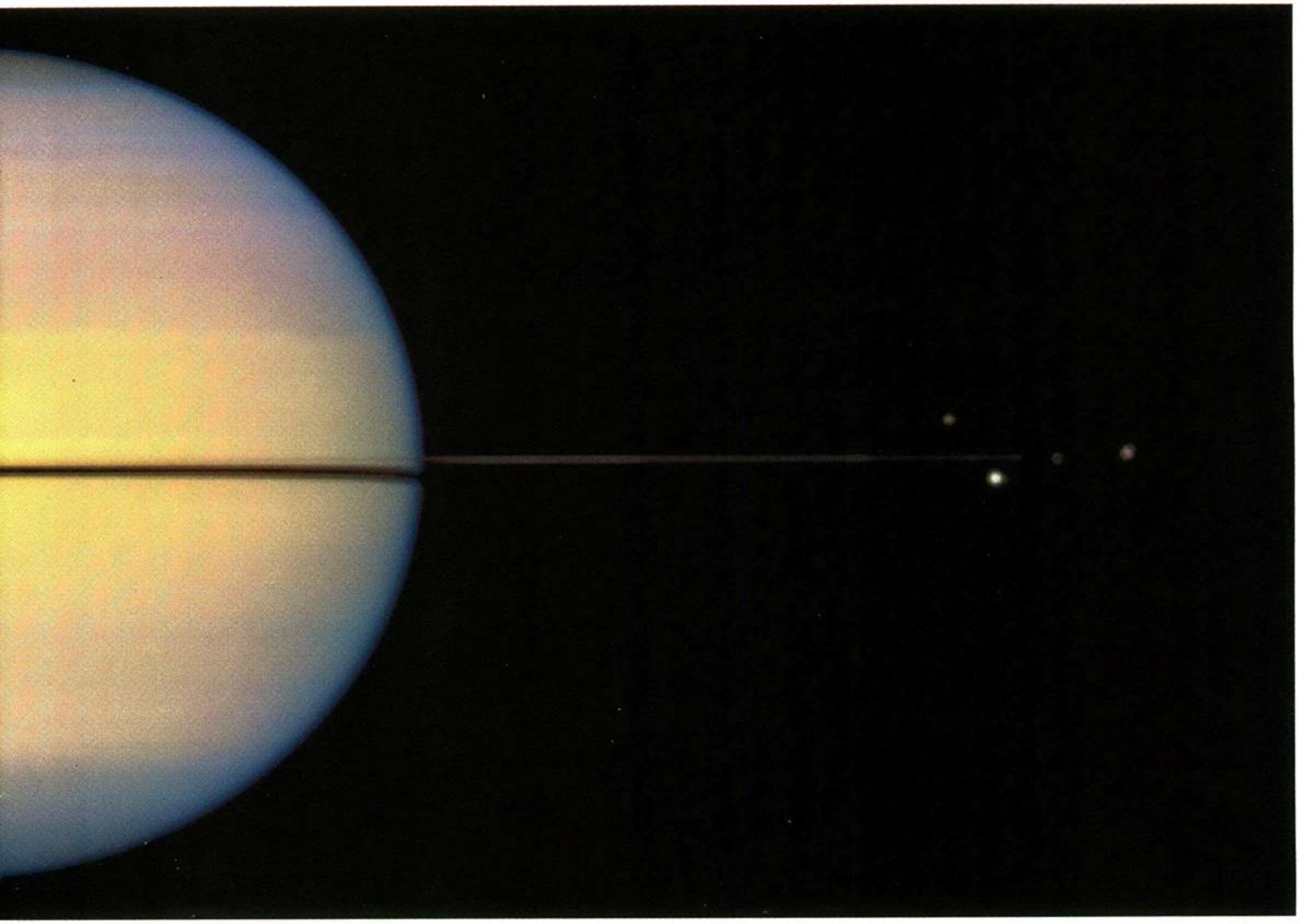
Erich Karkoschka (Univ. of Arizona) and NASA



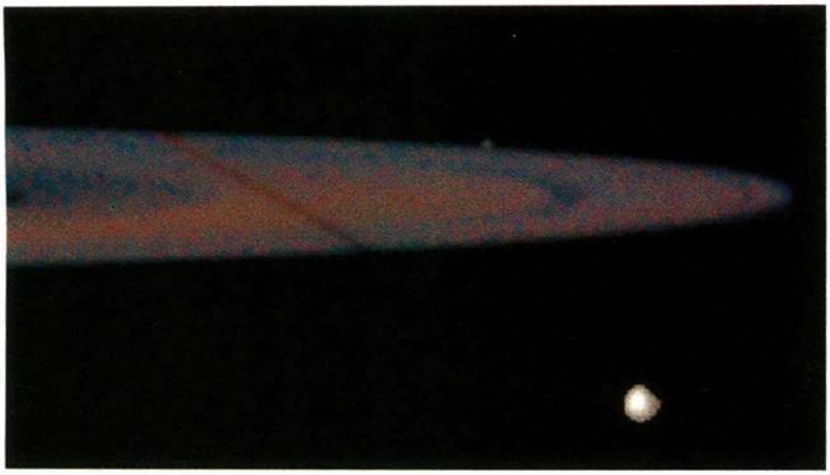
Erich Karkoschka (Univ. of Arizona) and NASA

WHEN VOYAGER 2 FLEW BY Uranus in 1986, it found the solar system's seventh planet to be a rather monochromatic aqua-blue in visible light (inset). But by looking at Uranus in infrared wavelengths, Hubble brings out features in the hydrogen-rich atmosphere unobservable in visible light. Three distinct layers of haze show up in red (the highest altitude), yellow, and blue, helping astronomers better understand Uranus' cloud decks. Uranus' south pole appears nearly face-on, it's the only planet in the solar system with this tipped-over orientation.

Image processing brings out the charcoal-black rings. Four of Uranus' tiny inner moons can be seen: Portia (top), Puck (right), Belinda (just below Puck, very faint), and Juliet (bottom). All four moons are less than 150 kilometers across. Hubble's images revealed that Uranus' rings and satellites are more varied in color than previously thought.



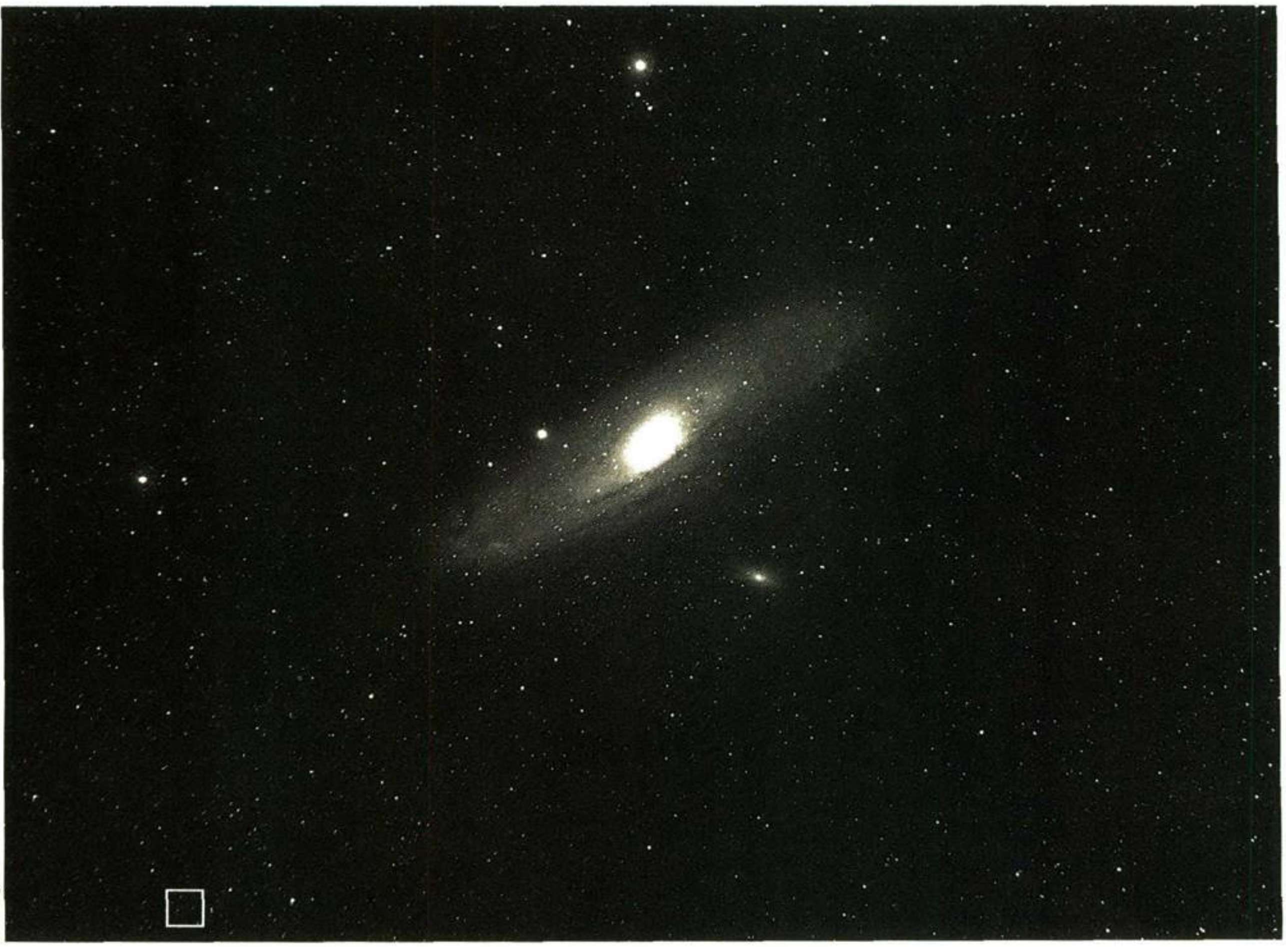
ON AUGUST 6, 1995, HUBBLE took this snapshot of Saturn when the planet's rings appeared almost perfectly edge-on. The rings are so razor thin – only a football-field thick – that they are practically invisible when seen edge-on. The dark band across Saturn is actually the shadow of the rings. Saturn's largest moon Titan (left) casts the round shadow on Saturn's southern hemisphere. Titan has a thick, high-altitude layer of haze that gives the cloud-enshrouded moon its brownish appearance. The four medium-sized ice moons Mimas, Tethys, Janus, and Enceladus (left to right), are located on the far right. Tethys, the largest of these four moons, is 1,050 kilometers across. Janus, the smallest of the four, is about 200 kilometers across. Two tiny moons, Prometheus and Pandora, are just barely visible in front of the right tip and left tip of the ring, respectively. Scientists are comparing these images to images taken during the Voyager flybys to learn more about the dynamics of Saturn's and Titan's atmospheres.



Erich Karkoschka (Univ. of Arizona) and NASA

DIMINUTIVE DIONE, only 1,120 kilometers wide, casts a 200,000-km-long shadow on Saturn's rings, a distance spanning more than halfway between Earth and the Moon.

Hubble images helped scientists confirm a 30-year-old theory that sunlight, charged particles, and micrometeorites vaporize frozen water in the rings, forming a thin "atmosphere" of gas surrounding the rings. Even at the current rate of evaporation, more than three tons per second, the rings will still survive for at least another billion years. This image is a detail from the cover photograph.



Bob English

WHEREAS HUBBLE REVEALS thousands of stars in the globular cluster G1 (opposite page), G1 barely registers in this ground-based photo of the Andromeda Galaxy (M31). The globular is a tiny blip inside the box. It is so faint that it doesn't appear on most star maps. G1 is approximately 130,000 light-years from Andromeda's nucleus.

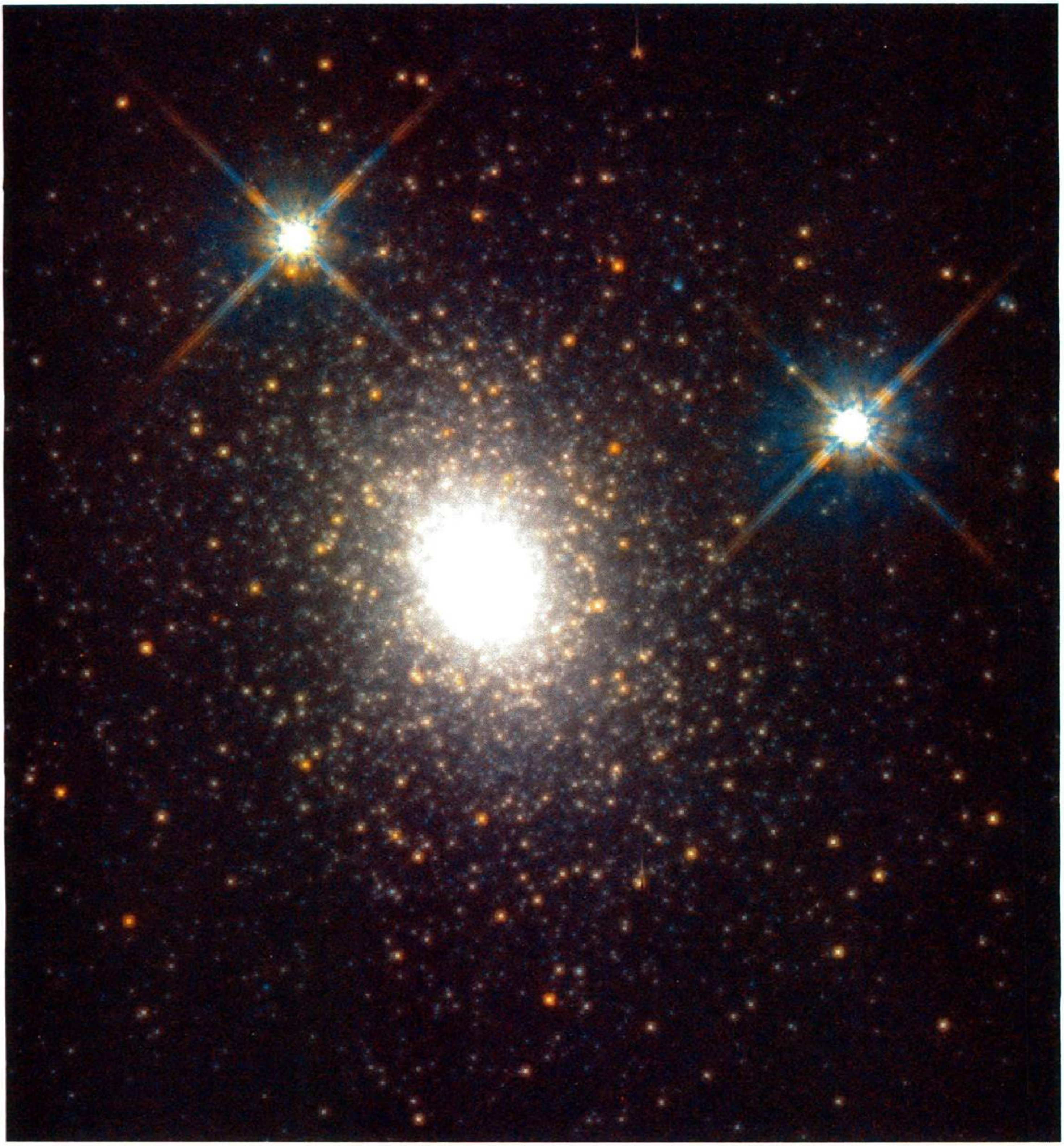
On April 24, 1990, space shuttle Discovery astronauts deployed a 12.5-ton satellite the size of a city bus. Expectations were high for this $2.3-billion satellite, for it was the Hubble Space Telescope. From its vantage point high above the distorting effects of Earth's atmosphere, Hubble's mission was to provide humanity with unprecedented photographs and information that would transform our view of the universe.

Mission accomplished. Hubble has lived up to expectations, offering ultra-sharp views of planets, comets, stars, disks, jets, rings, nebulae, galaxies, quasars, clusters, and just about every other type of celestial object known to science. In some instances, Hubble spectacularly confirmed cherished theories of how the universe behaves. In others, Hubble sent astronomers back to the drawing board.

Oh, there were some glitches. The manufacturer of Hubble's 2.4-meter mirror ground it to the wrong shape. It was only off by one-fiftieth the width of a human hair, but that was enough to compromise Hubble's major scientific objectives. But in December 1993, astronauts Jeffrey Hoffman, Kathryn Thornton, Story Musgrave, and Thomas Akers performed a house call 600 kilometers above Earth's surface, installing corrective lenses and making other upgrades and repairs. With its new pair of "glasses," a refurbished Hubble was unleashed on the universe.

To celebrate Hubble's 6-year anniversary, NASA released these photographs. Like the hundreds of images that have already been released, the new images show off the telescope's versatility. Photos of Saturn and Uranus demonstrate how the telescope serves as a surrogate space probe, keeping regular watch on our planetary neighbors. Another photo resolves 5,000 stars in a rich star cluster orbiting the Andromeda Galaxy, a cluster that shows up as an indistinct blip in ground-based telescopes. Hubble also zoomed in on the core of the Whirlpool Galaxy 23 million light-years away, providing a detailed view of the maelstrom surrounding a supermassive black hole. Finally, Hubble peers deep into space and time, catching the gravitationally distorted light of a newborn galaxy undergoing a burst of star formation.

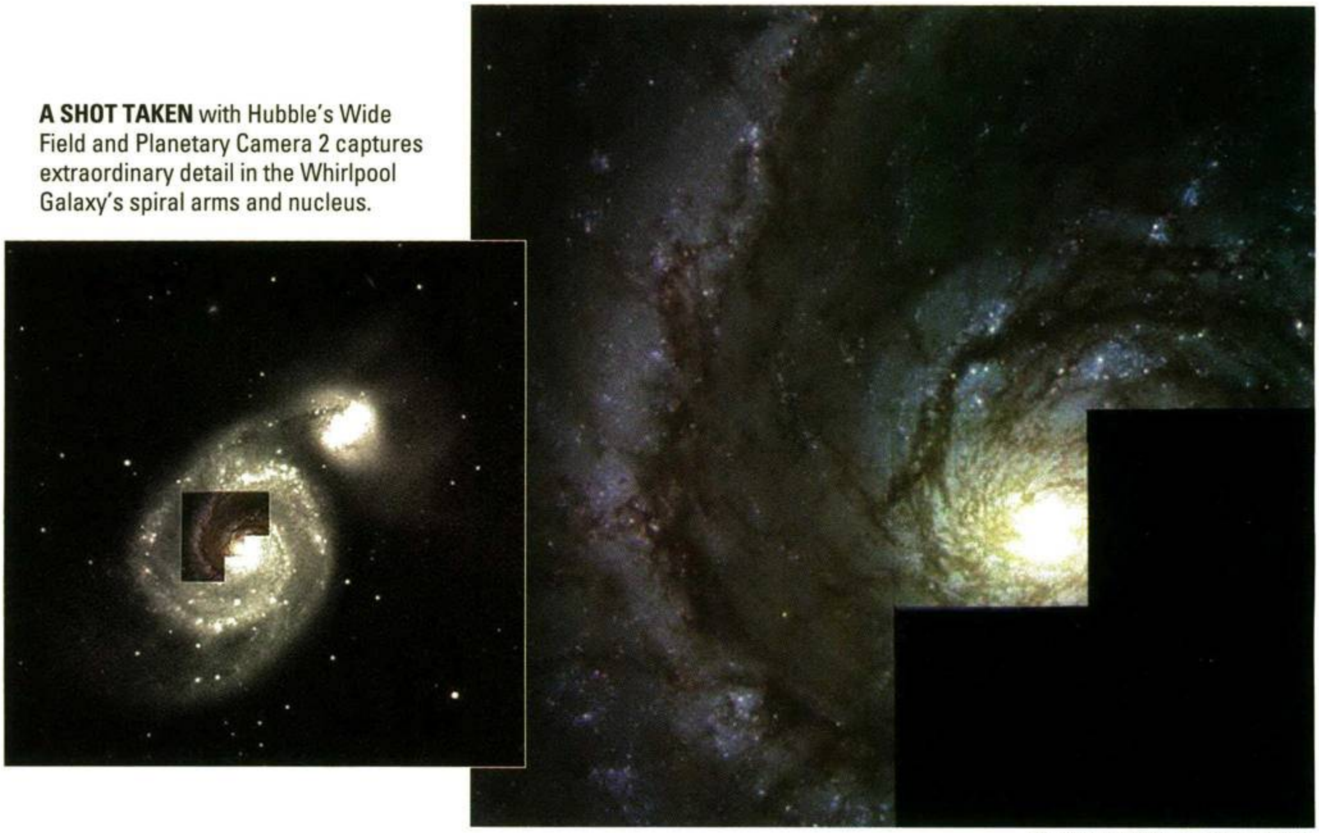
Happy birthday Hubble! May your next six years of life be as fruitful as the previous six. ☐



Michael Rich (Columbia Univ.), et al., and NASA

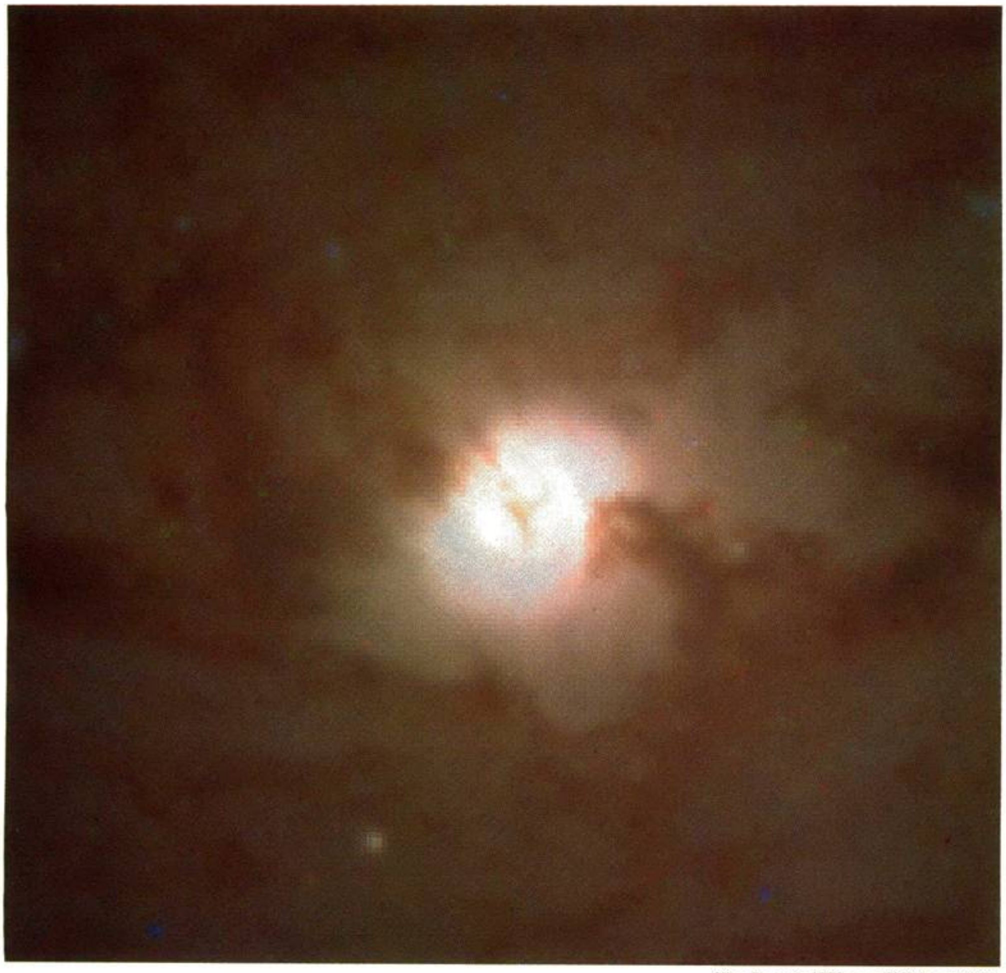
LOOK FAMILIAR? This globular cluster belongs to the great Andromeda Galaxy (M31), 2.2 million light-years away. This is the first time another galaxy's globular cluster has been seen so clearly. Hubble's amazing resolution brings out the level of detail ground-based telescopes see in Milky Way globular clusters that are hundreds of times closer.

The cluster, called G1, contains roughly one million stars and is the most massive globular cluster in the Local Group of galaxies. Roughly 5,000 individual stars – mostly red giants – can be seen in this image. Compared to globular clusters orbiting the Milky Way, G1 has a higher abundance of heavy elements, suggesting that Andromeda and the Milky Way have different star formation and cluster formation histories. Hubble will observe 20 more Andromeda globular clusters in the next 2 years.



A SHOT TAKEN with Hubble's Wide Field and Planetary Camera 2 captures extraordinary detail in the Whirlpool Galaxy's spiral arms and nucleus.

Nino Panagia (STScI and ESA) and NASA

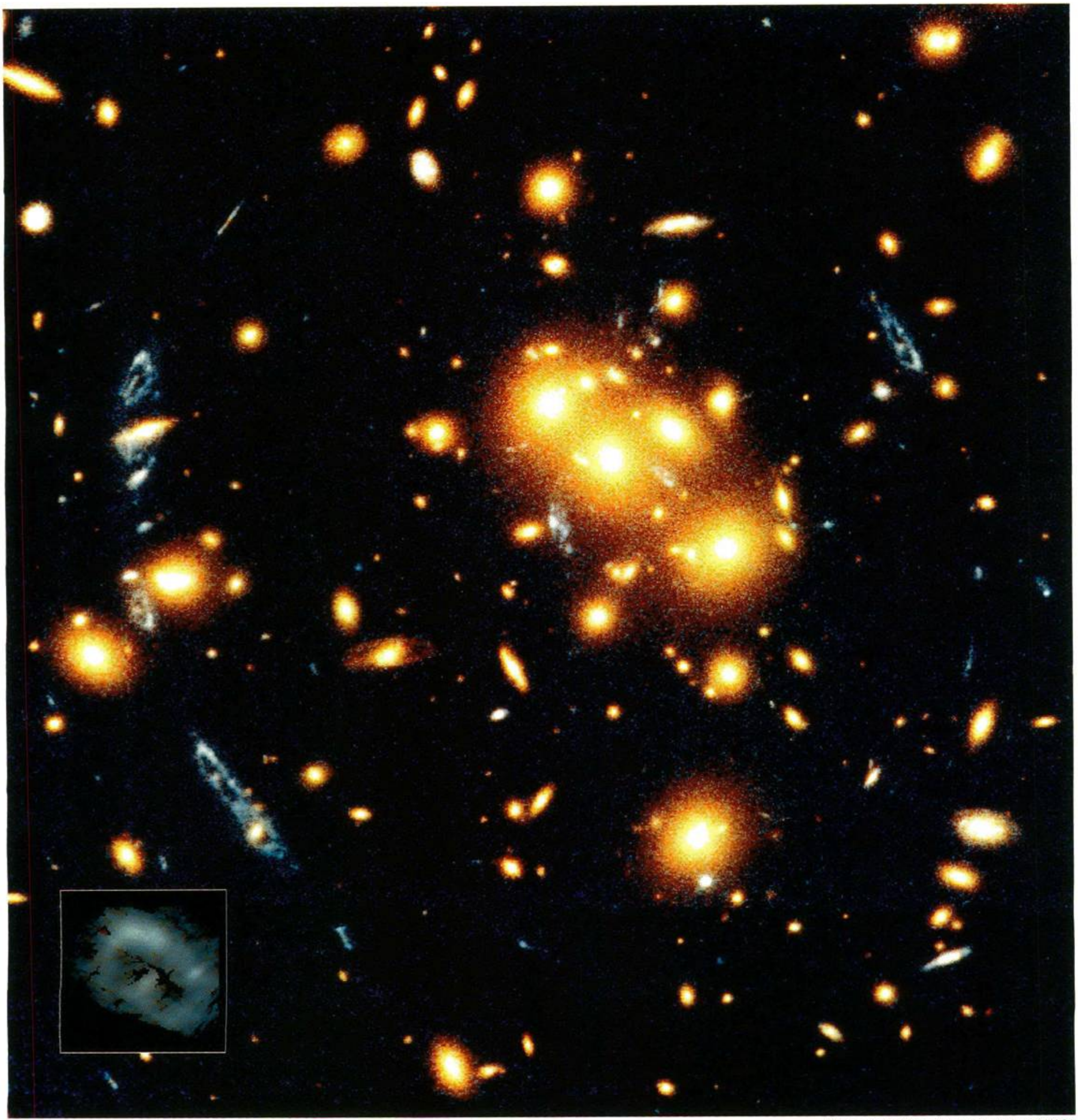


Nino Panagia (STScI and ESA) and NASA

THE CENTRAL MAELSTROM of the Whirlpool Galaxy (M51), 23 million light-years away in Canes Venatici, is unveiled by Hubble. The bright sphere of light is the actual core, measuring 80 light-years in diameter. Millions of young stars are crammed into this region, which has a stellar density 5,000 times higher than the solar neighborhood. Residents of this district would see a continuous bright sky.

Bands of dust at the galactic center form a "Y." The bright spot at the heart of the Y is less than 5 light-years across, yet contains a congregation of stars with a combined brightness of 1 million Suns – suggesting that a monster black hole reigns supreme in the core. Beyond the central region lies a zone of much older stars. At the outer edge of the image, only 700 light-years from the core, there is a hyperactive star formation region that is churning out thousands of new stars.

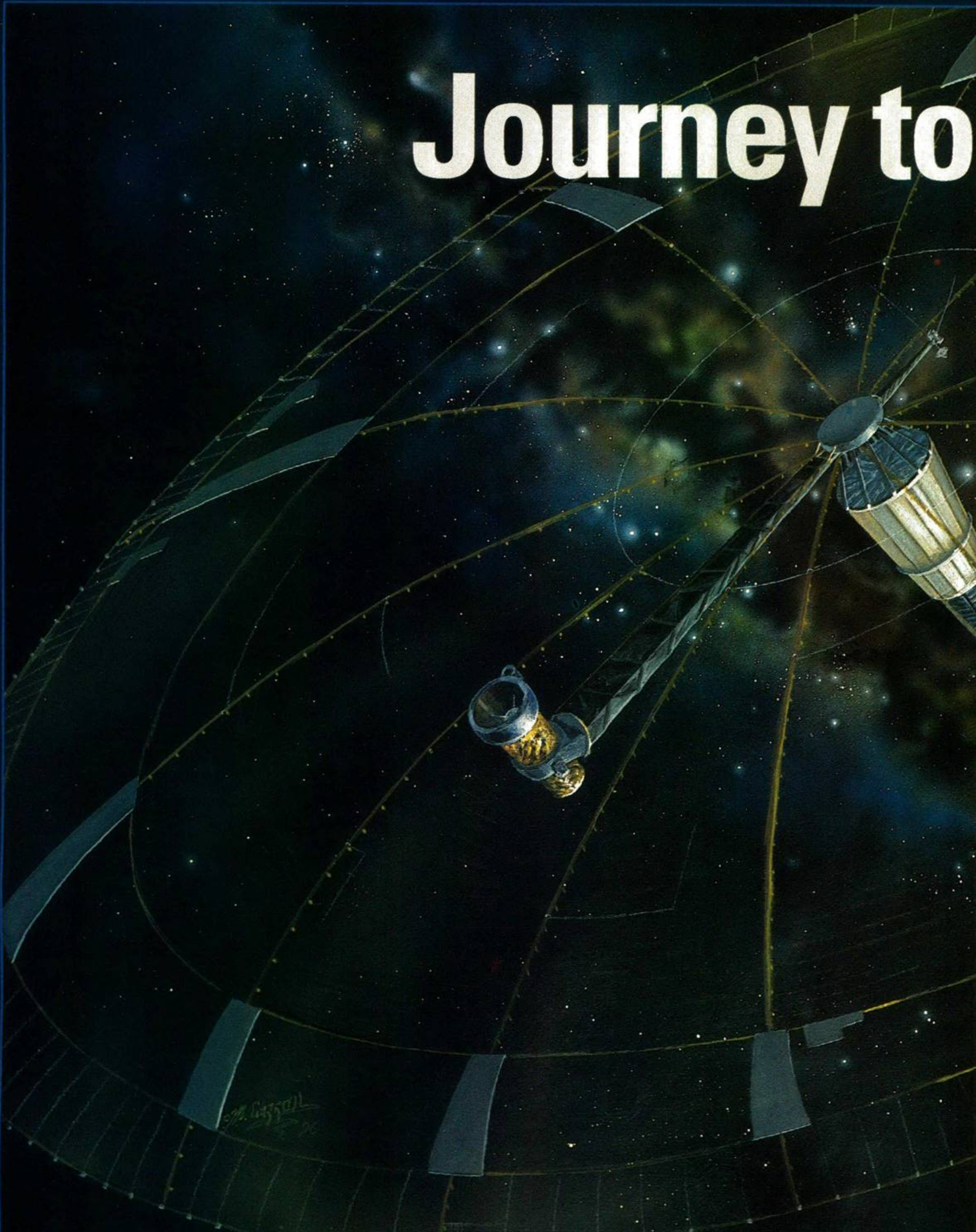
Because young stars generally aren't found so close to galactic cores, astronomers think they formed when a dwarf companion galaxy ventured close to the core 400 million years ago. The close encounter stirred up the dust, triggering the intense star formation.

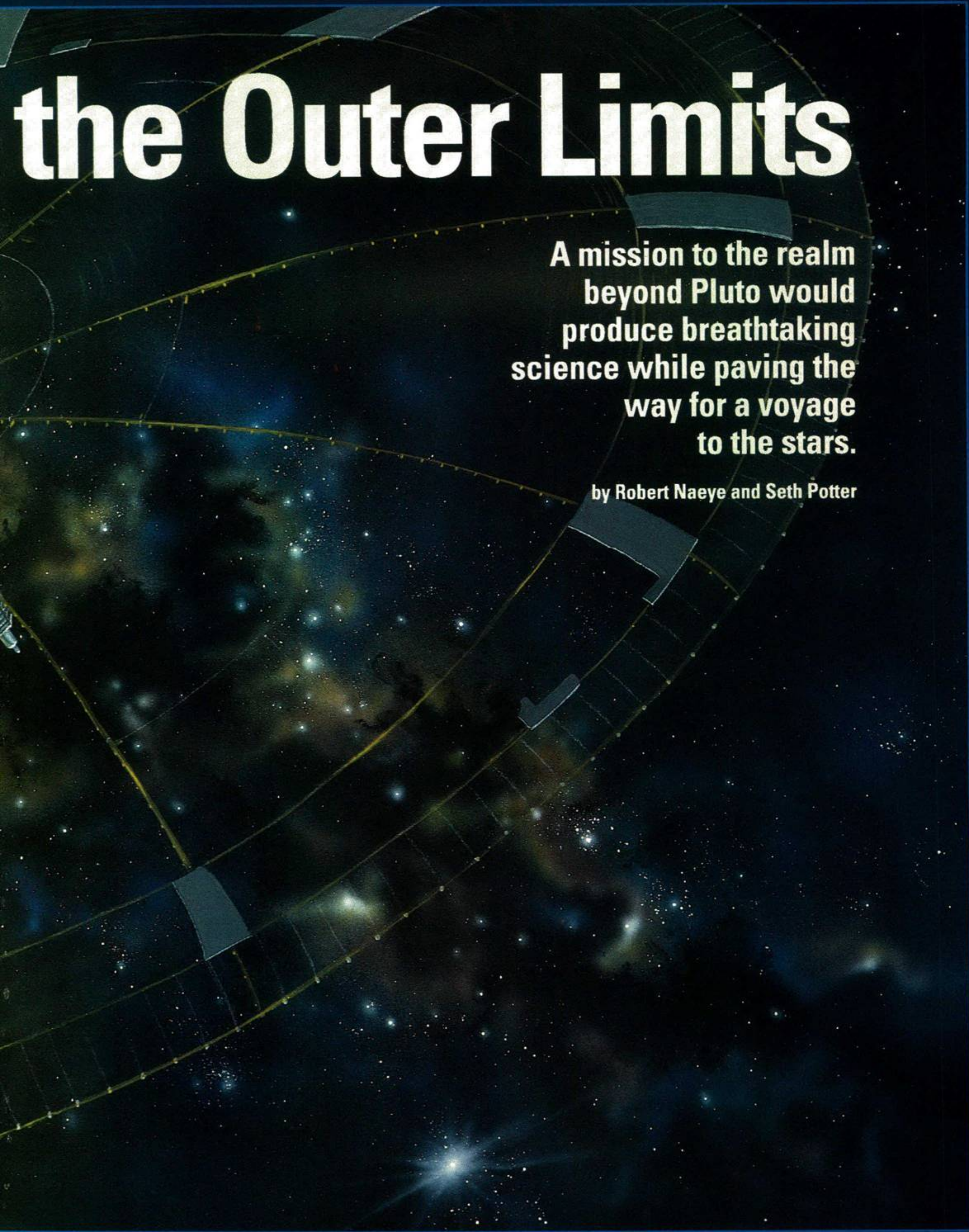


Wesley Colley (Princeton Univ.), et al., and NASA

EINSTEIN PREDICTED that the gravity of a huge concentration of mass could act as a lens, amplifying and distorting light from more distant objects. He also predicted that humanity would never be able to observe this effect. As this Hubble image shows, Einstein was right on only one account. The yellow galaxies in the center belong to the cluster 0024+1654, about 5 billion light-years away. The blue arcs are multiple images of a galaxy roughly 10 billion light-years away whose light has been gravitationally lensed by the cluster. Astronomers have seen such lenses before, but Hubble's resolution allowed Wesley Colley and Edwin Turner of Princeton University and J. Anthony Tyson of Bell Labs, to reconstruct the shape of the distant galaxy (inset). The team discerned features in the galaxy only 300 light-years across. The white areas within the blue ring are pockets of star formation, and the dark region inside the ring contains the dusty raw material from which stars are born. Astronomers will continue using Hubble to spot other lensed objects that would otherwise be too faint to be seen.

Journey to





the Outer Limits

A mission to the realm beyond Pluto would produce breathtaking science while paving the way for a voyage to the stars.

by Robert Naeye and Seth Potter

Michael Carroll

A long journey begins with a single step.
— Chinese proverb

Forget about the starship Enterprise whizzing through the Galaxy at warp speed, encountering fertile planets and exotic aliens at every stop. Stripped of its glamorous, fictional veneer, real space travel is boring and ponderous. Proxima Centauri, the nearest star beyond the Sun, lies 4.25 light-years away. That translates to 40,000,000,000,000 kilometers of space sprinkled with little more than the occasional hydrogen atom or dust grain.

The Voyager and Pioneer spacecraft, traveling at 61,000 kilometers per hour, would take 75,000 years to reach Proxima Centauri if they were pointed in that direction. To reach Proxima within a human generation a spacecraft would have to travel at least 1,500 times faster than Voyager. Even launching a small robotic probe on such a mission would require technological breakthroughs of untold proportions, and expenditures exceeding the gross national product of the United States. Clearly, people aren't going to the stars anytime soon.

But there is something humanity can do right now to at least lay the groundwork for its first giant leap to the stars. We can launch a mission to probe the space far beyond the planets, a vast hinterland between the domain of the Sun and the domain of interstellar space. A voyage to this unexplored frontier would have plenty of interesting things to see and do. It could survey diminutive ice worlds, watch the last vestige of the once-powerful solar wind vie for supremacy with its counterpart from the Galaxy, sample interstellar space, and conduct revolutionary astronomy to alter our view of the universe.

And exploring a new region of trans-solar space out to a thousand astronomical units would help spawn the technology needed to go to the stars. (An astronomical unit, or AU, is the average distance Earth is from the Sun, about 150 million kilometers.) Such a mission bridges the crucial gap between a Voyager-style interplanetary mission and a true interstellar mission across the vast depths of space.

"Any probe that one generation sends will be bypassed by later probes," notes astrophysicist and science fiction author David Brin. "So when does it ever make sense to launch? Early missions are going to need intermediate justifications. A mission to this region of space, I believe, is a wonderful objective."

Study groups at NASA's Jet Propulsion Laboratory and in Europe have arrived at the same conclusion. Specifically, NASA's Thousand Astronomical Unit (TAU) would explore where interstellar space begins and measure exact distances to stars in our Galaxy.

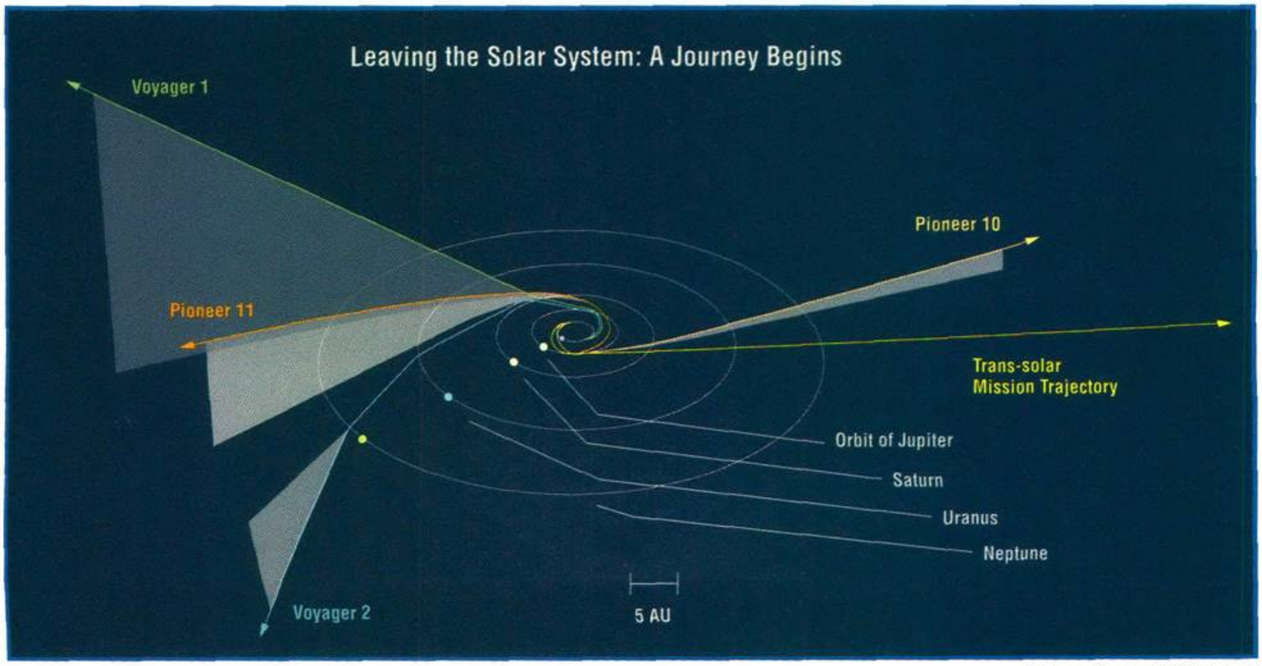
A trans-solar spacecraft would communicate with light.

The European-based study boldly proposes using the Sun's gravity as a giant lens from 550 AU and beyond.

Through these studies, humans are sizing up for the first time what it would take to mount a trans-solar mission and reap the scientific bounty.

Touring to the Edge

First on a trans-solar spacecraft's agenda after leaving behind the realm of the planets would be a survey of icy worlds that populate a zone called the Kuiper belt. The spacecraft starts encountering these objects

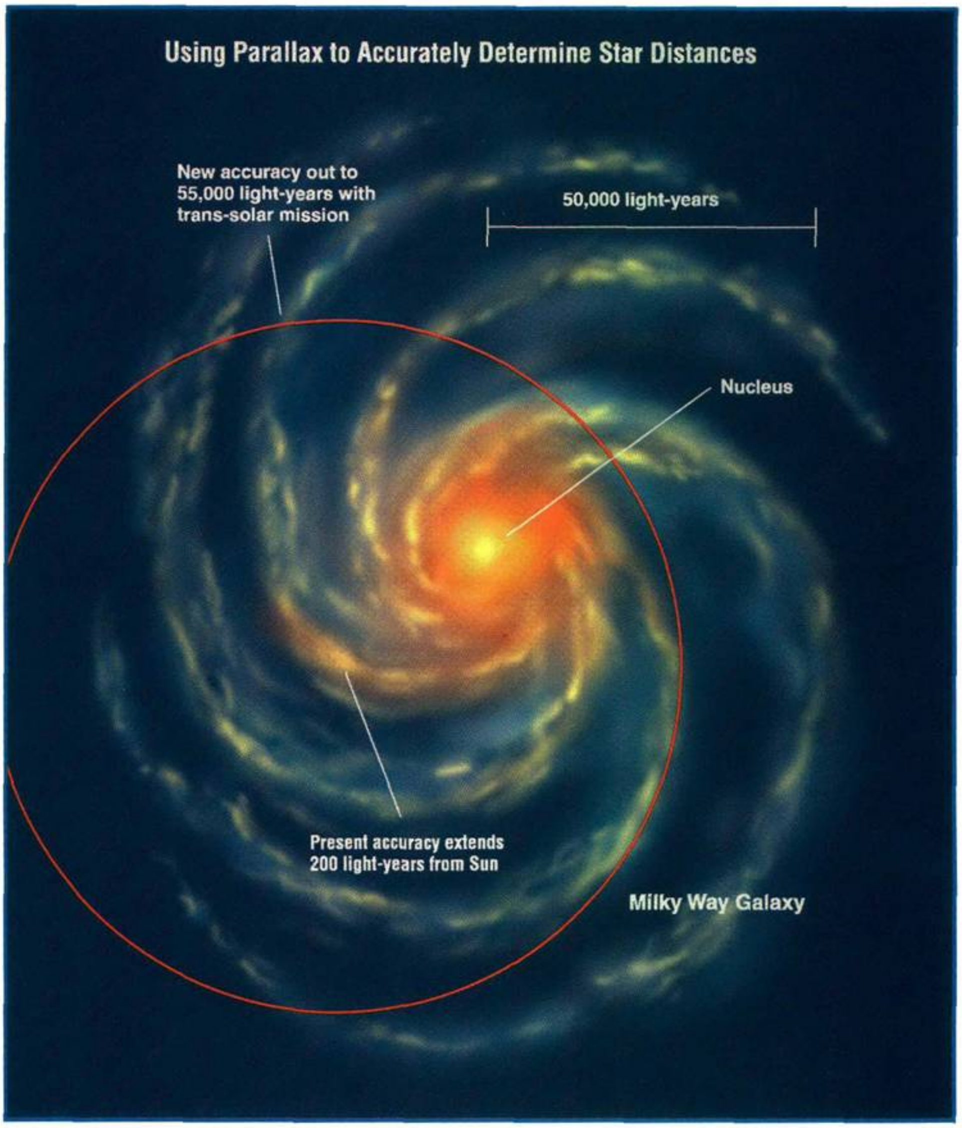


All illustrations by Phil Kirchmeier

soon after it soars beyond the orbit of Pluto at 39 AU. Astronomers have already discovered more than 30 of an estimated ten billion Kuiper disk objects, the largest of which are full-fledged mini-planets several hundred kilometers across (see "The Remarkable Odyssey of Jane Luu," February 1996). But even in Hubble Space Telescope images, the remote, icy worlds appear as tiny smudges. A trans-solar spacecraft would afford a closer look to determine the compositions and histories of these elusive objects.

Somewhere between 110 and 160 AU the spacecraft would cross a boundary that marks the true outer edge of our solar system — the heliopause. At the heliopause the ever-thinning stream of charged particles flowing from the Sun — the solar wind — weakens to the point where the stellar wind from 100 billion stars in the Galaxy overwhelms it.

This collision of titans, a scaled-up version of King Kong versus Godzilla, generates powerful bursts of radio waves detectable from Earth. The spacecraft would find out what else happens at this boundary and beam back detailed information.


Using Parallax to Accurately Determine Star Distances

New accuracy out to 55,000 light-years with trans-solar mission
50,000 light-years
Nucleus
Present accuracy extends 200 light-years from Sun
Milky Way Galaxy

Beyond the heliopause is an opportunity to sample undisturbed interstellar dust grains. Some interstellar material does make its way into the inner solar system after having fought its way inward against the solar wind (see "Motes in the Solar System's Eye," May 1993). But such grains interact with the Sun's magnetic field and other solar system particles, so they're far from uncontaminated by the time they reach Earth's environs. By studying pure interstellar material, scientists can learn more about deep space.

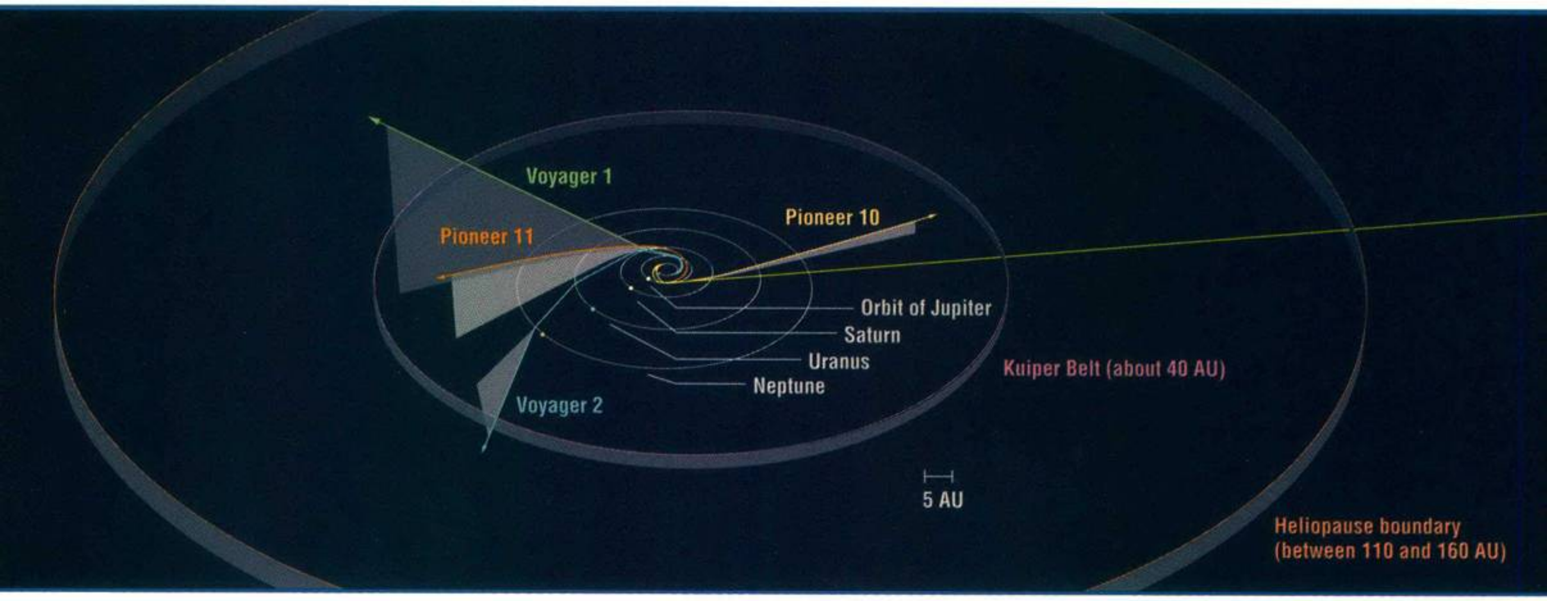
A Trans-Solar Traveler's Technical Challenges

- Spacecraft autonomy due to communication lag time
- Lasers, microwave communication
- Develop nuclear ion drive
- Refine solar sails

The spacecraft can also observe pristine cosmic rays, subatomic particles that have been accelerated to near-light speeds by supernovae. Some cosmic rays reach Earth, but the frequency of cosmic rays varies with the 11-year solar activity cycle. "Something in the vicinity of the heliopause is acting as a barrier to the cosmic rays," says University of Iowa space physicist Don Gurnett. "We would like to know where this modulation of cosmic rays occurs."

Astronomy from the Edge

At several hundred AU, a 1-meter telescope mounted on a trans-solar craft could help astronomers pinpoint the distances to faraway stars in our Galaxy. Currently, astronomers can directly measure stellar distances only within 200 light-years using a method called trigonometric parallax. Astronomers measure the position of a star and then measure it again six months later. Just as a pen held at arm's length appears to shift against the background as you move your head, Earth's movement over six months gives astronomers a 2 AU baseline (300 million km) to measure a nearby star's shifting



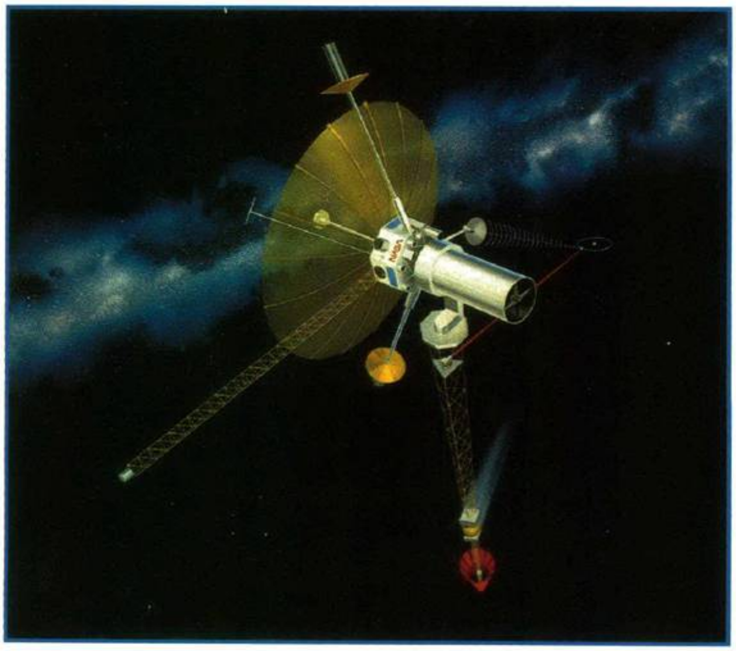
position against the background of more distant stars. With that measurement, calculating a distance becomes an exercise in high school trigonometry.

Even with a 2-AU baseline, however, astronomers cannot accurately measure the minute positional changes of stars more than 200 light-years away. But a very distant spacecraft and Earth would form a baseline several hundred AUs long. "This would bring the entire Galaxy within reach of our astronomical caliper," says Italian physicist Claudio Maccone. Astronomers would map whole tracts of the Galaxy in great detail and calibrate distance indicators that serve as yardsticks for objects in remote galaxies. Pinning down the distances to such faraway objects is crucial in determining our universe's age.

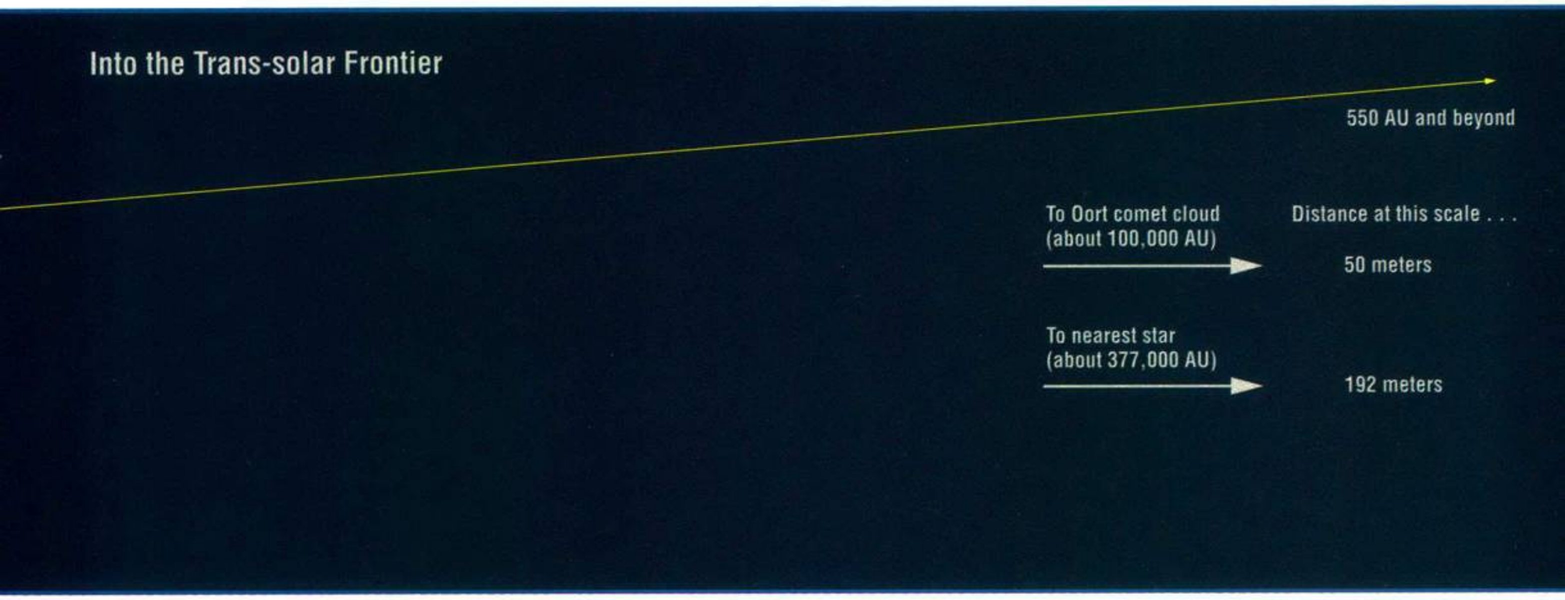
When it gets far enough from Earth, the spacecraft will take advantage of one of the peculiar quirks of Einstein's general theory of relativity — gravitational lensing. At 550 AU and beyond, the Sun acts as a gravitational lens. It focuses and amplifies light from more distant objects. Objects directly behind the Sun suddenly appear much brighter, allowing an onboard infrared telescope to image Earth-sized planets orbiting distant stars. If a spaceship with a radio telescope was launched in the opposite direction of the Milky Way's center, it could make detailed radio maps of the gas and stars that swirl around the monstrous black hole thought to lie in the galactic core. The faint radio whispers of an extraterrestrial civilization might sound like a shout to a small radio antenna.

Monitoring the radio signals from a trans-solar spacecraft also lets astronomers detect subtle ripples in the fabric of space-time known as gravitational waves, which are another one of Einstein's bizarre predictions.

According to general relativity, extraordinarily violent astrophysical processes such as colliding black holes and supernovae unleash gravitational waves. Such a wave passing through the solar system would gently rock both Earth and the spacecraft back and forth, like a ship rolling on a wave. The resulting disruption in an experimental microwave link with Earth would tell astronomers that perhaps a pair of billion-solar-mass black holes coalesced in a distant galaxy.


NASA

HUMANITY'S FIRST STEPS into the Galaxy might come in the form of a spacecraft like this. In this rendering of NASA's Thousand Astronomical Unit (TAU) mission, an optical scope sits opposite from a radio telescope. A red laser beam serves as the craft's communication link to Earth. Microwaves are part of an experiment that measures gravity ripples in the fabric of space. The TAU mission would last about 50 years.



Toward a Smarter Starship

But a jaunt to our solar system's edge holds much more than a bonanza for scientists. There's a technological benefit for humanity that comes from flexing the engineering skills required to sail the stars. A trans-solar mission stimulates developments in fields such as communications, propulsion, guidance systems, and artificial intelligence.

Solar sails would harken back to the days of square-riggers.

To cover such vast distances within a human lifetime, the spacecraft must travel faster than 362,000 kilometers per hour, nearly 10 times faster than Voyager. Accelerating a spaceship to this velocity presents an enormous technical challenge. Another problem is keeping the spacecraft functioning properly over so many years in the cold depths of space. And communicating with faraway Earth becomes a difficult task.

Yet these problems are surmountable with current or near-term technology. As propulsion expert and retired Hughes Aircraft physicist Robert Forward says, "Interstellar flight is no longer impossible, just merely difficult. There are not one, but many future technologies under intensive development that can give the human race a starship that will take us to the stars."

One challenge is to make sure the instruments onboard the spacecraft are reliable and autonomous enough to function for decades. Because of the vast distances involved, the spacecraft must operate without extensive instructions from Earth. Signals from a spacecraft at 550 AU take three days to reach Earth, thus if a problem developed on the probe it would take that long for mission controllers to find out about it. Even after controllers figure a fix, another three days are needed for signals to travel from Earth to the spacecraft. Basic troubleshooting quickly swells into a multi-week process.

Space engineers experienced this nagging distance problem first hand when a balky tape recorder plagued NASA's Galileo probe to Jupiter. After scientists detected the problem and commanded the recorder to shut down, they concocted a fix and transmitted new playback and rewind commands that avoided a bad piece of tape. Technicians had to wait 40 minutes for the command to get to Galileo, plus another 40 minutes to see if the fix indeed worked. This cumbersome cycle was feasible in Galileo's case, but if those minutes became days due to distance, troubleshooting a spacecraft might become impossible.

Overcoming problems like these lets a trans-solar venture evolve into a valuable learning tool for computer designers. An autonomous onboard processor

Science on a Trans-Solar Mission

- Explore the Kuiper Belt
- Probe the boundary between the heliopause and interstellar space
- Sample uncontaminated interstellar dust grains
- Detect pristine cosmic rays
- Measure star distances out to 55,000 light-years
- Harness the Sun's gravity as a lens to make radio maps of Galaxy's core, detect faint ET signals, and discover Earth-sized, extra-solar planets
- Detect long wavelength gravity waves

would receive up-to-the-minute reports on all aspects of the craft's health. If, say, a data recorder gets stuck, a sensor relays information to the onboard computer rather than to Earth. The computer then figures out a solution instantly from a distance of a few centimeters or less, not billions of kilometers.

A communication lag time even factors into our ability to control the probe's flight path. To use the Sun as a gravitational lens, the spacecraft must be aligned very precisely with the Sun and the target that's being studied. A six-day round trip for course correction signals would make such precision impossible. Again, the probe must, in a limited sense, "think" enough to aim itself.

"It is difficult to go to the stars, but not impossible."

Even communicating with a trans-solar traveler challenges mission engineers. The far-ranging probe should be lightweight enough to accelerate rapidly, yet its antenna must be large enough to transmit a tightly-focused communication beam. A huge, heavy radio dish that flexes under acceleration and warps over time is out of the question. However, recent advances in laser technology make it possible to communicate over a beam of light.

Both light and radio are forms of electromagnetic radiation. However, light has a shorter wavelength. Because the size of a dish needed to accommodate a signal depends on the wavelength being used, communicating over a beam of light makes for a smaller receiver/transmitter dish, which in turn translates into lighter spacecraft. Moreover, lasers convey data over great distances with greater fidelity and at a much faster rate than radio.

So instead of a dish, a trans-solar spacecraft would carry a telescope up to one meter in diameter to focus a communications beam. And the power drawn by a transmitter/laser would be surprisingly low, perhaps 10 watts. Less power used for communicating means more energy for science.

On Wings of Mylar

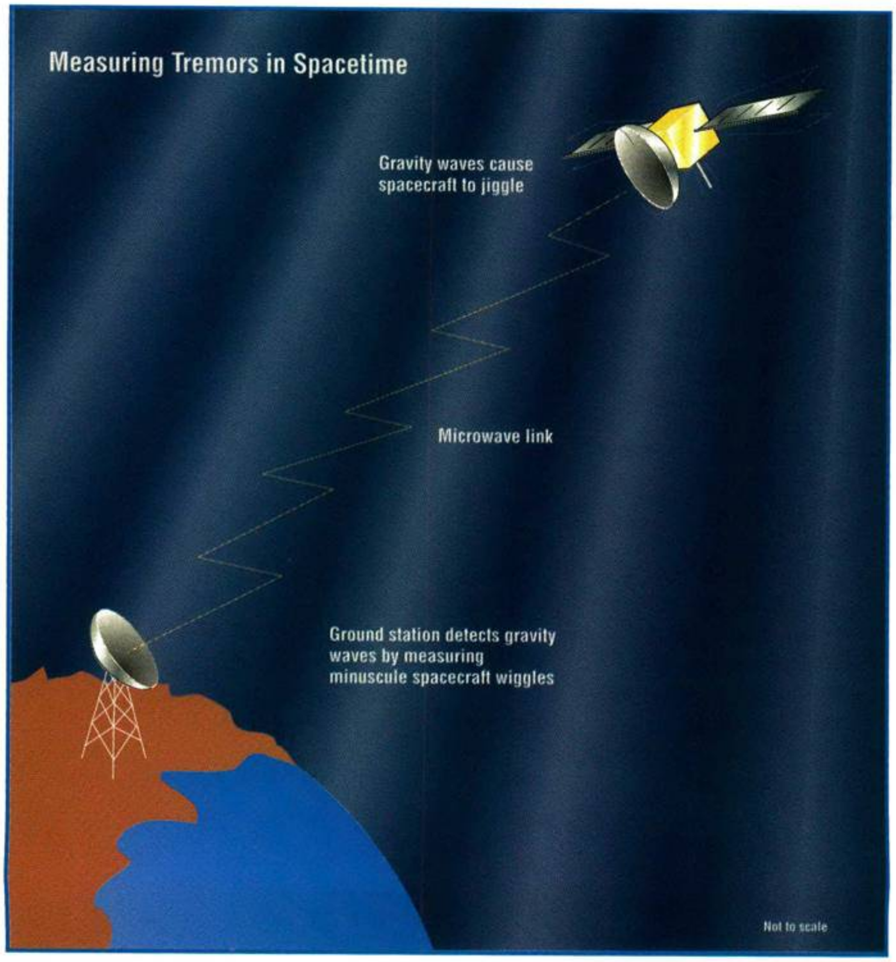
The immense distance covered by a trans-solar craft also challenges propulsion engineers. Although a voyage out to 550 AU covers only 1⁄500th of the distance to the nearest star, it still involves traversing 14 times Pluto's distance from Earth. Chemical rockets that have served us so well are not up to sending a probe that far within a human lifetime.

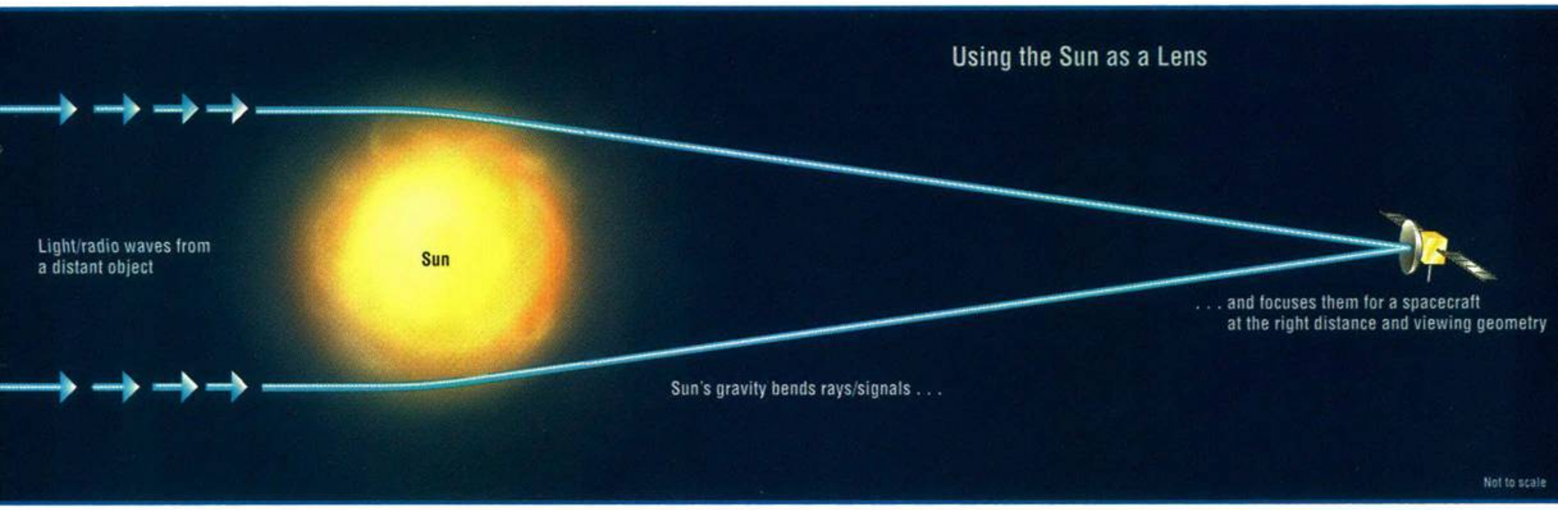
For all its complexity, a chemical rocket is nothing more than a device that shoots hot gas out one end. In order to conserve momentum, the rocket moves in the opposite direction. Thus, the rocket obeys Newton's Third Law of Motion, which says that for every action, there is an equal and opposite reaction.

A spaceship that carries its own fuel has a fundamental disadvantage — the rocket must accelerate both the mass of the spaceship and the mass of the fuel. Because of this problem, enormous quantities of fuel are needed to accelerate a rocket to a high velocity. The amount of chemical fuel needed to propel a probe to a distance of 550 AU within 50 years is enough to power several thousand space shuttle launches. A natural question to ask is: Can one use less propellant, but shoot it out the back of the spacecraft faster?

The answer is yes. This

Measuring Tremors in Spacetime


Gravity waves cause spacecraft to jiggle
Microwave link
Ground station detects gravity waves by measuring minuscule spacecraft wiggles
Not to scale



Using the Sun as a Lens

Light/radio waves from
a distant object
Sun
Sun's gravity bends rays/signals . . .
. . . and focuses them for a spacecraft
at the right distance and viewing geometry
Not to scale

can be done with an electric or ion engine. The propellant is an ionized (electrically charged) gas; typically, mercury vapor. The ions are accelerated out the back of the engine by means of an electric field. Electrons produced during the ionization process must also be ejected from the spacecraft so that it does not build up an electric charge.

The power used to ionize the gas and produce the electric field can be supplied by several different means. For example, NASA has designed a spacecraft that uses solar cells to power the ion thruster. Missions beyond the solar system, where sunlight is dimmer, might use a method that combines a power-generating nuclear reactor with an ion engine known as nuclear electric propulsion (NEP). Although NEP has not yet been used on a space mission, it involves a combination of known technologies. Ion propulsion (nuclear powered or otherwise) has, however, too little thrust to lift a mass from the surface of Earth. Thus, an ion-propelled probe would have to be launched by conventional rockets.

A more elegant propulsion method, the solar sail, harkens back to the days of square-riggers. Like catching a breeze on an interplanetary ocean, solar sails use the pressure sunlight exerts on a large, thin, and highly reflective sail to accelerate a spacecraft slowly outward from the Sun. (This is not the same phenomenon as the solar wind, which consists of charged particles.) Science and engineering instruments would ride on booms that attach to the sail.

The disadvantage solar sails pose is their large areas of extremely thin (2- to 3-micron-thick) material. A probe whose mass is the same as the recent Clementine lunar probe (225 kg) would require a sail about a quarter mile wide, weighing one-half to one and one-half tons. Maintaining the sails' shape and position would require an intricate latticework to support the fragile fabric. Solar sails would also provide a slower rate of acceleration: Flight time to several hundred AU is about 50 or 60 years. To achieve this, the sail would be unfurled close to the Sun, where sunlight pressure is strongest.

That's what the California-based World Space Foundation planned to do when it proposed a solar sail probe to Mars in 1992. Prototype sails were in fact built, but never flown. Nevertheless, the technology to build 2-to-3 micron-thick sails is here now. Even thinner sheets have been produced experimentally. As in the case of ion propulsion, a conventional rocket or space shuttle would be needed to launch the probe from Earth.

Slow Crawl into the Cosmos

By the time a trans-solar spacecraft reaches 550 AU, it has traveled about 1/120th of a light-year. A mission to the nearest star, Proxima Centauri, would need to travel 500 times farther still. Nevertheless, the experience gained in a 550 AU mission is invaluable in paving a way to the stars. "An extrasolar mission promises great scientific rewards and offers humanity the opportunity to prepare and practice its interstellar capability in the near future," says New York University propulsion expert Gregory Matloff.

The types of propulsion considered the most likely candidates for a mission to several hundred AU are not the only ones possible. Studies of true interstellar flight use nuclear fission, or even fusion, for direct heating of an exhaust stream. A more exotic possibility is to use antimatter, which becomes almost pure energy when it comes into contact with ordinary matter. Alternatively, a powerful space-based laser can accelerate a sail. Such propulsion systems might someday take us to the stars; we could test them on a mission to 550 AU.

Developing any type of spacecraft to reach that distance takes a great deal of effort. But it is a worthwhile effort, for as Robert Forward writes in his book *Indistinguishable from Magic*, "It is difficult to go to the stars, but not impossible." We don't know exactly what we'll see when we go beyond the solar system, but it is likely to be something that spurs us on to the next step in our travels — a leap into the interstellar void. ☐

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A River In the Universe

A 1 billion light-year-wide river of galaxies could spell trouble for cosmology.

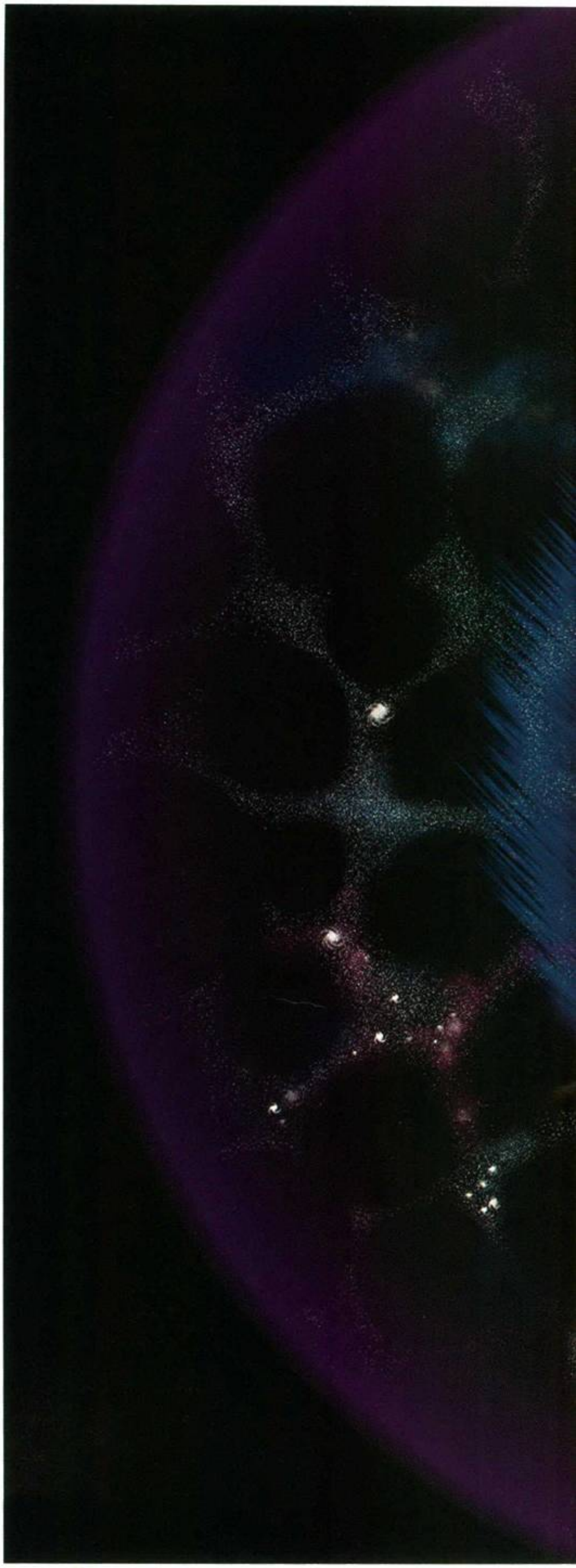
by Adam Frank

Have you ever woken up feeling bleak, wondering just where the world is heading? Astronomers have been sensing that a lot lately. But it's not just the world they are worried about, it's the entire universe.

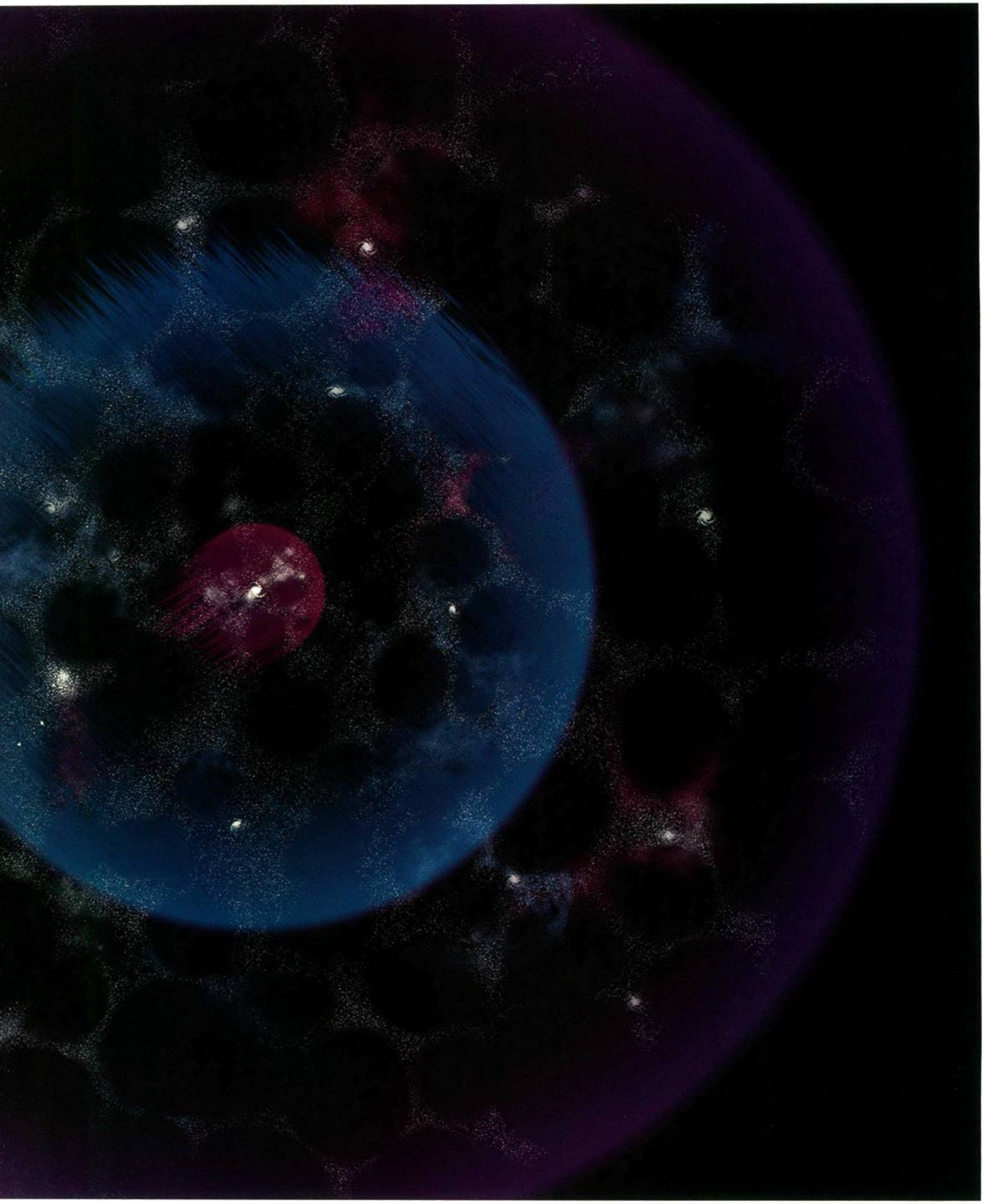
Four years ago an ambitious pair of young astronomers, Tod Lauer of Kitt Peak National Observatory in Arizona and Marc Postman of the Space Telescope Science Institute in Baltimore, Maryland, looked deep into the night sky trying to confirm a prediction made by every respectable cosmological theory. On very large scales, these theories said, the universe should be moving just one way — outward. The only visible motion should be a smooth expansion driven by a big bang some 10 to 20 billion years ago.

That is not the way it worked out. Instead, Lauer and Postman found that a huge chunk of the universe appears to being heading off "thataway," toward some far off point in the direction of Virgo. They had discovered a vast current of matter, a bulk flow of galaxies superimposed on top of the universe's smooth expansion.

Lauer and Postman's results sent shock waves through the world of cosmology. If all that mass is moving on so large a scale, then the big bang was not as smooth and uniform as virtually all modern cosmological theories demand. As one astronomer put it, "If this result is true then we know less than nothing."



ASTRONOMY: Rick Johnson



Lauer and Postman's river in space might be a pivotal cosmological discovery sending researchers back to the drawing boards to rework theories of our cosmic origins. Because of Lauer and Postman's work, new studies of large-scale motions are sprouting like flowers in spring as astronomers look to confirm or, perhaps, overturn Lauer and Postman's results. A group of Harvard astronomers recently reheated the debate, claiming to have evidence that directly contradicts Lauer and Postman's findings. What is the real answer? In these heady times for astronomers, that is the key question as everyone tries to figure out which way the universe is really going.

The Great Attractor

To understand the meaning of Lauer and Postman's discovery, we need to go all the way back to the big bang. The primordial fireball that spawned the universe propelled all the "stuff" in it outward in all directions.

"If this result is true then we know less than nothing."

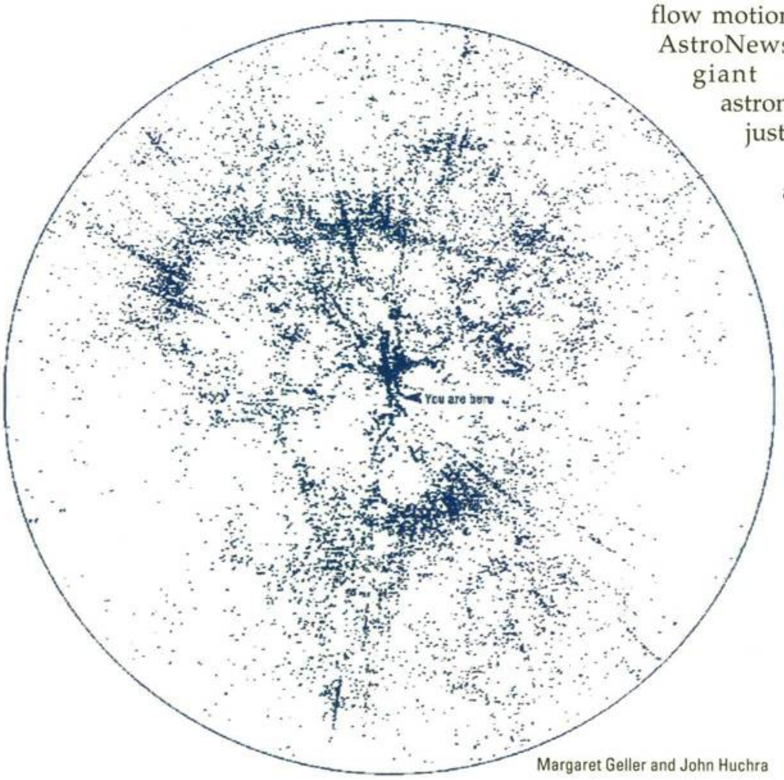
Astronomers believe that the universe in its earliest epochs expanded so quickly that any large-scale clumps had to be smoothed out. But as the universe expanded and cooled, matter slowly coalesced into the diverse structures — galaxies, stars, planets — we now see in the sky. By cosmological standards though, these things are pretty small. On large enough scales, astronomers believe the universe should retain the uniformity of its origins. As Lauer puts it, "The universe is a lot like the ocean. Standing at the shore you see waves and bubbles and foam. But if you look at it from an airplane, it looks smooth and uniform."

Gravity is the force that forms structure, and the larger the structure, the more time gravity needs to make it. If the universe hasn't been around long enough in your cosmology theory for gravity to make the largest structures, then your cosmology theory has problems.

But astronomers have already identified enormous structures: galaxy superclusters and "Great Walls" of galaxies extending across hundreds of millions of light-years of space. These structures of matter produce motions as their gravitational forces yank galaxies and other clusters one way or the other. But all of these motions are tiny ripples superimposed on top of the universe's smooth expansion.

In 1986 a team of astronomers known as the Seven Samurai discovered that a 200-million-light-year-wide region of space (including our Local Group of galaxies) is moving in the direction of Hydra and Centaurus at a speed of 530 kilometers per second (1.2 million mph). The Seven Samurai proposed that a vast and distant concentration of matter they called "The Great Attractor" was responsible for this bulk flow motion (see "Core of Great Attractor Found," AstroNews, June issue). The implied size of this giant swarm of matter stunned most astronomers. Theory can still account for it, but just barely.

As Einstein said, all motion is relative and has to be measured in what astronomers call a frame of reference, or a "rest frame." For the motions caused by the Great Attractor and all other large-scale structures, the cosmic microwave background provides astronomers with a celestial rest frame. The cosmic microwave background is the faint hiss of radiation left over from the big bang. It fills the sky, giving the universe a nearly uni-



Margaret Geller and John Huchra

GREAT ATTRACTORS. Galaxies are not randomly distributed, they cluster together in enormous walls that span hundreds of millions of light-years. These vast concentrations of matter pull surrounding galaxies toward them, imposing localized "rivers" within the outwardly expanding universe.

form temperature of 2.7 kelvins. Fine-scale measurements, however, show that one side of the sky is slightly hotter than the other. This temperature "dipole" is a result of the Milky Way's motion with respect to the cosmic microwave background. Our motion toward Leo makes the background appear hotter in that direction. This gives astronomers a standard with which to refer all other measurements of motion.

Tod Lauer and Marc Postman

IN THIS CORNER... Tod Lauer (left) and Marc Postman have thrown a monkey wrench into standard cosmology. By analyzing the brightest galaxy in 119 clusters (like the one above), they discovered a vast river that theory can't explain.

Marc Postman

Light a Standard Candle

In the spring of 1989 Lauer and Postman began a project to extend the results of the Seven Samurai. But it wasn't structure they were looking for, it was the *end* of structure. "Marc and I thought that if the Great Attractor accounts for all the large-scale motions not due to expansion, then if you look way beyond it, like three or four times farther, then you should see those motions die out," explains Lauer.

What Lauer and Postman were looking for is something astronomers call "convergence," the distance at which all motion can be attributed solely to the universe's expansion. Neither they nor anyone else could imagine structures affecting the vast size scales they planned to study: the sphere of space 600 million light-years around the Milky Way. It was natural to assume they would only see the expansion of the universe, an expansion known as the Hubble flow.

They used distant galaxy clusters to probe for convergence. By measuring the redward Doppler shift of light from a cluster, it's easy to get the cluster's total velocity. Most of this velocity is due to the Hubble flow. The Hubble flow is characteristic of explosions, the farther one chunk of debris is from another chunk, the faster they move apart from each other. The universe's expansion, therefore, provides a quick way of gauging distances because the stuff that's moving

It wasn't structure they were looking for, it was the *end* of structure.

fastest should be farthest away, a relationship called the Hubble Law.

But Lauer and Postman's goal was to find the motions of the clusters that were *not* due to expansion. To do that they needed another way to measure distance that was independent of redshifts and the Hubble Law. Because objects appear fainter as their distance increases, Lauer and Postman got their independent distance measure by comparing how bright an object appears to be with how bright it really is. To do this they needed a "standard candle" — an object whose intrinsic brightness is known — to make their measurements of the distance to each cluster.

The brightest galaxies in each cluster tend to be equally bright, making them good candidates for Lauer and Postman's standard candles. This galactic standard candle acts as a check on the redshift-derived distances; any difference in the two distance values indicates motion superimposed on top of the universe's expansion. By comparing the redshift derived distances for these galaxies against their brightness derived distances, Lauer and Postman could extract information about bulk flows and convergence.

An even more radical possibility is that the big bang spewed more matter and energy in one direction than in the other.

Interpreting the Impossible

As soon as Lauer and Postman analyzed the data from the brightest galaxies in 119 clusters, they realized they weren't getting convergence. After looking all over the sky, they found that their standard candles were brighter in one direction than in the other.

"We asked what systematic velocity could be added to bring all the galaxies back to the same brightness," says Lauer. The answer to that question was startling. Uniform brightness could be achieved only by assuming that all the clusters — in the 1 billion light-year-diameter region of space sampled in their survey — were part of a vast river of matter flowing 700 kilometers per second (1.6 million mph) in a direction more than 75 degrees away from the direction of the cosmic microwave background hot spot. If this bulk-flow motion is the Amazon, the motion caused by the Great Attractor is a mere subcurrent within the vast river.

This was not the result they were expecting. "We were pretty upset at first," says Lauer. "We had expected convergence, so we thought something was wrong." They performed every test they could think of, but the brightness discrepancy in their data would not go away.

"To understand this bulk-flow motion, you can picture a big deck on a ship," explains Postman. "Everyone is milling around the deck moving in their own little direction. If you get a big enough view, you'll find that everyone has a random motion. But the whole ship itself has a large motion in a single direction that everyone is sharing."

Theories of the universe's origin and structure can just barely cope with the Great Attractor, but they have an even more difficult time explaining the cause of this astonishing motion. The 700 km/second river is only about 1/20th the universe's expansion rate at the distances probed by Lauer and Postman, so the result does not call the expansion of the universe into question. But according to just about every respectable cosmological theory, the universe was supposed to be smooth on the scale probed by Lauer and Postman. It hasn't been around long enough for gravity to create the enormous structures that would be responsible for this river in space.

"This result is *not* predicted by many theories," stresses Postman. "We tried to estimate the probability that popular cosmological theories could produce a universe with such a fast large-scale flow. We concluded there was a 2 percent to 5 percent chance of getting this." Those odds make a lot of astronomers uncomfortable. Your best theories should be able to produce the right answer without sweat, not just on rare occasions.

There are other interpretations for Lauer and Postman's result that have nothing to do with bulk flows. One possibility is that all the brightest galaxies on one side of the universe actually are systematically brighter than those on the other side. But why should that be the case? Many astronomers think this is a more revolutionary explanation than the existence of a billion light-year-wide river in space.

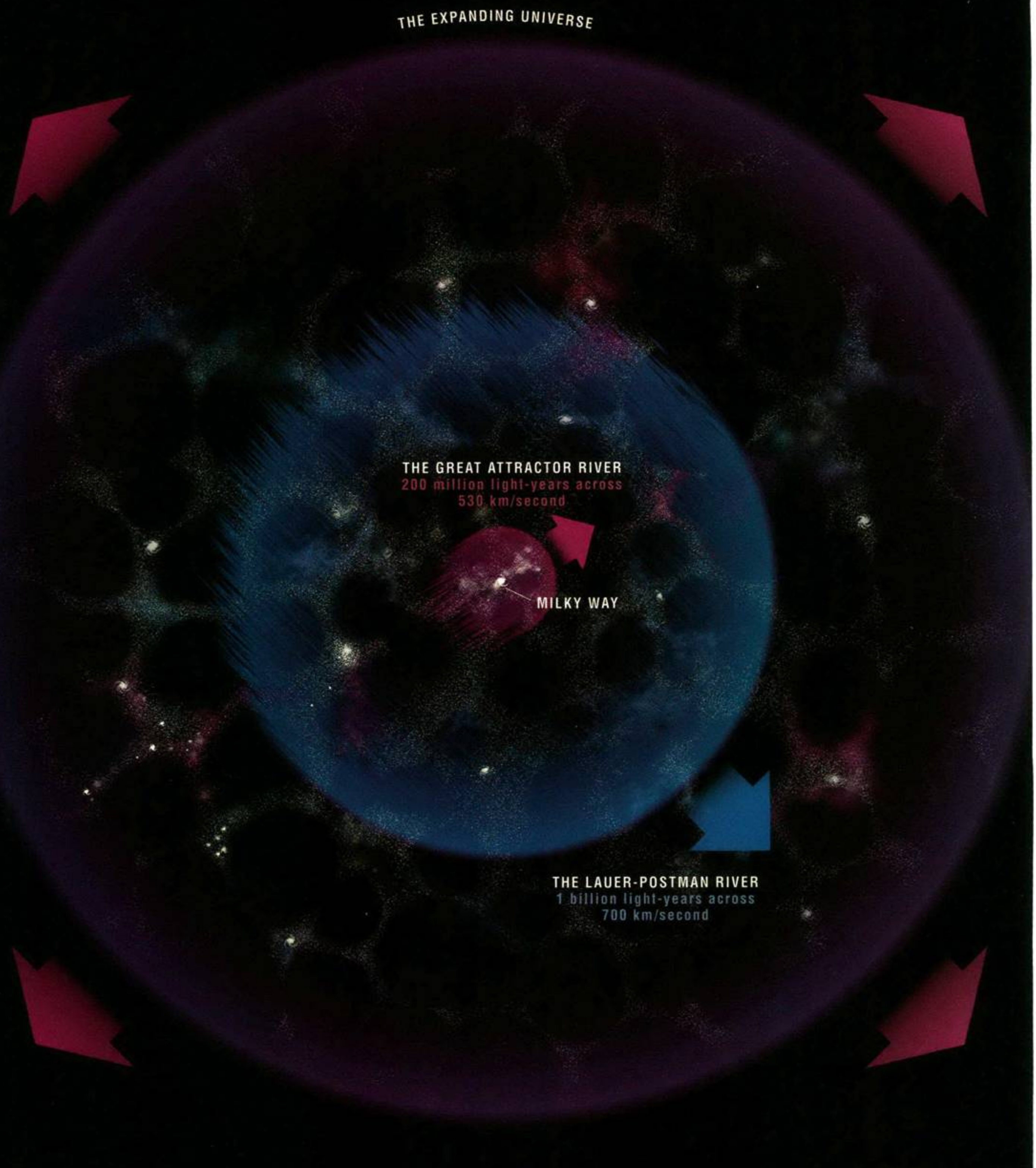
An even more radical possibility is that the cosmic microwave background can't be used as a reference frame. In that case, the temperature dipole has nothing to do with the Milky Way's motion. The universe really *is* hotter on one side than on the other, meaning the big bang spewed more matter and energy in one direction than in the other. It offends most astronomer's sensibilities to imagine any kind of lopsided universe. So, in spite of astronomers' misgivings about bulk flows, these alternative explanations are deemed even more difficult pills to swallow.

So, in the final analysis, Lauer, Postman, and the entire astronomical community have been left scratching their heads at the banks of an unimaginably vast river of galaxies.

The Supernova Connection

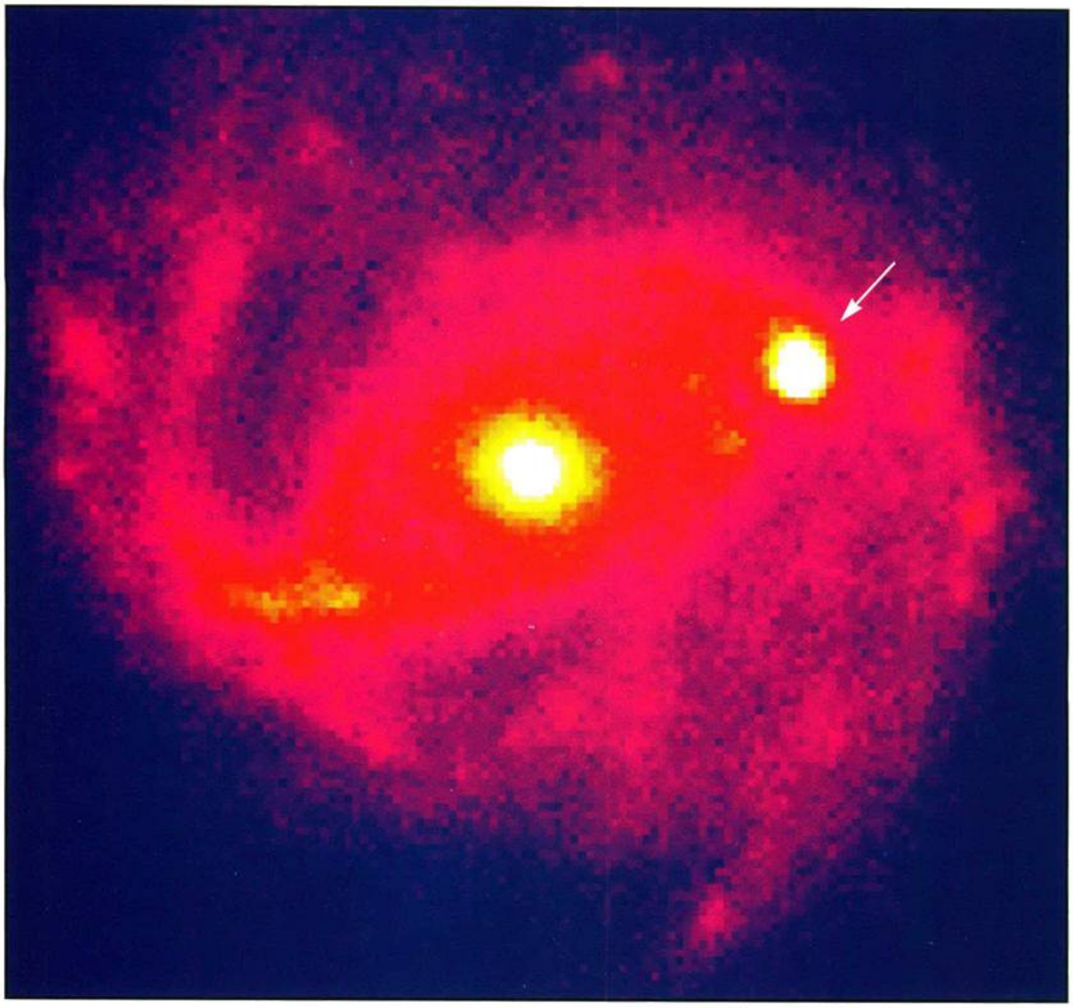
In the wake of Lauer and Postman's work, astronomers are pushing hard to find new ways to study large-scale motions. By probing distances com-

Cosmic Currents


THE EXPANDING UNIVERSE
THE GREAT ATTRACTOR RIVER
200 million light-years across
530 km/second
MILKY WAY
THE LAUER-POSTMAN RIVER
1 billion light-years across
700 km/second

Astronomers have discovered two great rivers of galaxies embedded within the expanding universe. Diagram not to scale.

ASTRONOMY: Rick Johnson



Adam Riess, William Press, and Robert Kirshner

AND IN THAT CORNER... By analyzing supernovae like this one in 20 distant galaxies, William Press (left), Adam Riess, and Robert Kirshner discovered a river that flows in the opposite direction as the one found by Lauer and Postman.

parable to those in Lauer and Postman's research, one project stands out among others. Recently Adam Riess, William Press, and Robert Kirshner, all of the Harvard-Smithsonian Center for Astrophysics, joined the fray with a new study that yielded a very different result.

Instead of relying on bright galaxies, the Harvard team used a different kind of standard candle to measure distances: type Ia supernovae (which arise when a white dwarf explodes). Being bright doesn't make a candle standard, however — some type Ia supernovae are brighter than others. But Mark Phillips of the Cerro Tololo Inter-American Observatory in Chile recently discovered that the way a type Ia supernova brightens and then dims yields its absolute brightness. This finding allowed the Harvard team to use type Ia supernovae as a standard candle.

Jon Chase (Harvard Univ.)

With their calibration method in hand, Riess, Press, and Kirshner derived distances to 20 galaxies up to 1.2 billion light-years away in which astronomers had observed type Ia supernovae. Unfortunately, only one of their galaxies overlapped Lauer and Postman's sample, not enough to make a meaningful comparison. Plotting these distances against velocities for the galaxies derived from the redshifts, the Harvard team produced an independent test of the Hubble Law. While their data beautifully confirmed the universe's expansion, small deviations showed slower motions to the north of the galactic plane than to the south.

Like Lauer and Postman's study, the Harvard study implied a bulk flow of galaxies. But there was a significant difference. As Riess puts it, "Our disagreement with Lauer and Postman is the direction of the motion. Our direction points toward the north." This is, essentially, the same direction as the hot spot in the

"It's very hard to fit their observations into any consistent framework."

microwave background. "The Lauer and Postman result," Riess continues, "points to the south."

The Good, the Bad, and the Errors

The Harvard study has clearly added a new twist to the bulk-motion debate. Now there are two different studies, each reaching out to similar distances, each finding different rivers in space. Both teams are made up of extremely competent scientists who are experts in their fields. Whose river of galaxies is real? Could both studies be right? Could both be wrong?

Some of the differences between the studies may lie in statistics and the errors inherent in the observations. There are also differences in the methods. "We have six times the number of data points, and our survey is better designed for addressing this particular problem than the Harvard survey," says Postman, noting that the Harvard study wasn't specifically designed to look for bulk-flow motion.

Now there are two different studies, each reaching out to similar distances, each finding different rivers in space.

The Harvard team counters that what they lack in quantity they make up in quality. Supernovae, they note, are individually more reliable distance indicators than the brightest galaxy in a cluster. "Lauer and Postman have done a very careful job, but the difference from one side of sky to the other in their work is very subtle. It is essentially a small effect," says Kirshner. Press adds, "You need huge concentrations of matter to make that acceleration. That degree of concentration is probably inconsistent with other evidence we have, for example, the smoothness of the cosmic microwave background. It's very hard to fit their observations into any consistent framework."

Because of these uncertainties, the ultimate answer is still unknown. So, as is usually the case with science, the only way to answer the question is to do more science. As you read this article, Lauer, Postman, and the Harvard group are busy gathering and analyzing more data in the hope of providing a definitive answer to the question of bulk flows.

Lauer and Postman's new study will include observations of more than 600 galaxies out to a distance of 1 billion light-years. This is truly a Herculean task in terms of data analysis, but the large number of objects should substantially reduce the uncertainties in their findings. Along with their measurements of the brightness of the brightest galaxy in each cluster, Lauer and Postman are performing additional measurements that should allow them to calibrate variations in their standard candles, further reducing their errors. Their initial results should be out sometime next year.

"We are still trying to see convergence," says Postman. "At some level we should eventually see the noncosmological motions decline. In addition, our extended sample may shed light on the alternative interpretation that there are large-scale variations in the brightness of these galaxies. If we look at the next shell of galaxies and find a completely different answer from what we found in the first study, then we know there's something funny about the galaxies themselves."

In the meantime, the Harvard group continues to hunt distant galaxies for new supernovae. They hope to have 35 by next year. "We are looking for more supernovae in Lauer and Postman's clusters to further enhance our results. By comparing the motion of supernovae to the motion Lauer and Postman infer in the same clusters, we may learn how the difference arises," says Riess.

The Waiting

While astronomers wait expectantly for the results of the new studies, it's worth remembering that the divergent streams of galaxies embodies a classic and exciting situation in science. When paradigms are shifting, completely contrary results exist side-by-side. The difficulties of cosmology, particularly the new values of the Hubble constant that make the universe look younger than the stars it contains, are now well known. These and other problems give the impression that astronomers are still groping for the right theoretical framework for asking basic cosmological questions.

"While you don't want to abandon an old friend," says Lauer, referring to the most popular versions of cosmological theory, "there was trouble brewing even without our results. Cosmology is now like trying to close an overstuffed suitcase. You can sit on it, cram it all down, and hopefully it will all fit in. But in the end it doesn't leave you with a good feeling."

The debate raging around bulk flows is one aspect of the larger debate about our cosmic origins. Some may find the uncertainty and confusion unnerving. But in reality, the debate shows how far we have come in our ability to build a scientific framework for answering such profound questions. As Kirshner puts it, "You don't want to settle cosmological questions by prejudice or stamping your feet. What's exciting about all this is now we really can make it an experimental science." □

Adam Frank is an astrophysicist who just moved to the University of Rochester. He was recently awarded the prestigious Hubble fellowship by NASA. His article "Starmaker" appeared in last month's issue.

Catch a Perseid on Film

This month's shower of bright meteors offers ample opportunity for backyard skyshooters.

by Patti A. Kurtz

Imagine looking into the tail of a comet hundreds of years after it passes Earth. What do you think you would see? Actually, we do this every time Earth experiences a meteor shower such as the Perseids, which peaks each year around August 12. The Perseid shower is one of the most prolific and certainly the most famous meteor shower. The shower results from Earth crossing debris left by Comet Swift-Tuttle (1862 III), whose last apparition was in 1992.

This year offers a great opportunity for Perseid watching. During peak Perseid activity — the shower peaks at 6 a.m. EDT on August 12 — the Moon will be out of the way, allowing the skies to be satisfyingly dark. Because of this, not only watchers but photographers who can capture streaks of Perseid meteors on film will want to tackle the Perseids with all the gear they've got. To survey the kind of photography that best records meteors, I spoke with a number of experienced skyshooters. What follows is their sage commentary on making the most of meteor photography. For specifics on the shower, see "Sky Almanac," page 56.

An Exploding Perseid Fireball
by Dan Smiley
(24mm lens, Fuji 400 ISO film, taken August 12, 1994)

Meteors, Cameras, Action . . .

To get started, you'll of course need a camera. Everyone agrees that a 35mm body (or a medium format if you can afford it) with a "B" (bulb) setting works best. The simpler the camera, the better — avoid automatic models that use batteries to hold open the shutter. With the lengthy exposures required by astrophotography, you would go through dozens of batteries with such a camera. Chris Wetherill of Pikes Peak Community College in Colorado Springs also suggests a camera with a "T" shutter speed, which denotes time exposure.

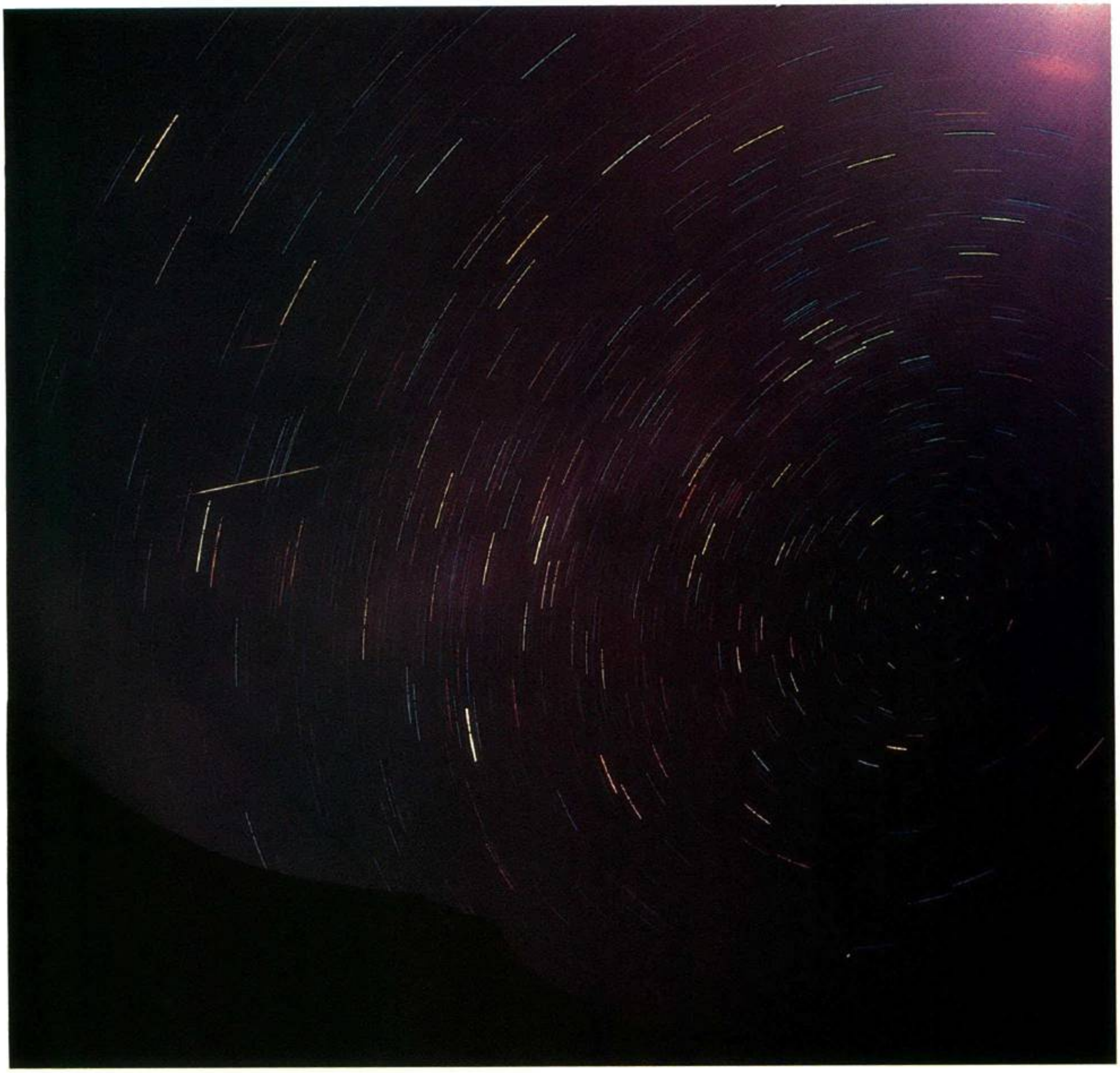
As far as specific models go, Mike O'Brine, known in Colorado Springs for his prime focus guided astrophotography, recommends the Olympus OM-1, Pentax K1000, Nikon FM/FM-2, Nikon F or F2, or the Minolta SRT 100/101/102 series. He suggests perusing the used camera market.

While you're at it, be sure you have a cable release. Don't skimp; if possible, find one which can be set and released with one hand.

Buy the best lens you can afford, says Michael Palermiti, staff scientist for Software Bisque. He suggests buying a lens with a speed of f/1.4. Gary Emerson of the E. E. Barnard Observatory in Golden, Colorado, agrees that it should be as "fast a lens as possible." He feels if the lens is slower than f/2.8, chances of recording anything but the brightest meteors are slim. A wide angle lens such as a 28mm will include a broad enough swath of sky to maximize the chances of catching a meteor, but a normal 50mm will suffice. During the exposure, this lens should be focused at infinity (∞).

The Universe of Film

When choosing film, keep your goal in mind. Do you want nice star trails with meteors shooting through the trails? Or, are you attempting pinpoint star images with meteors streaking through the picture? William Hollenbach of the Cederberg Observatory in Capetown, South Africa, has an opinion, although the Perseids is a



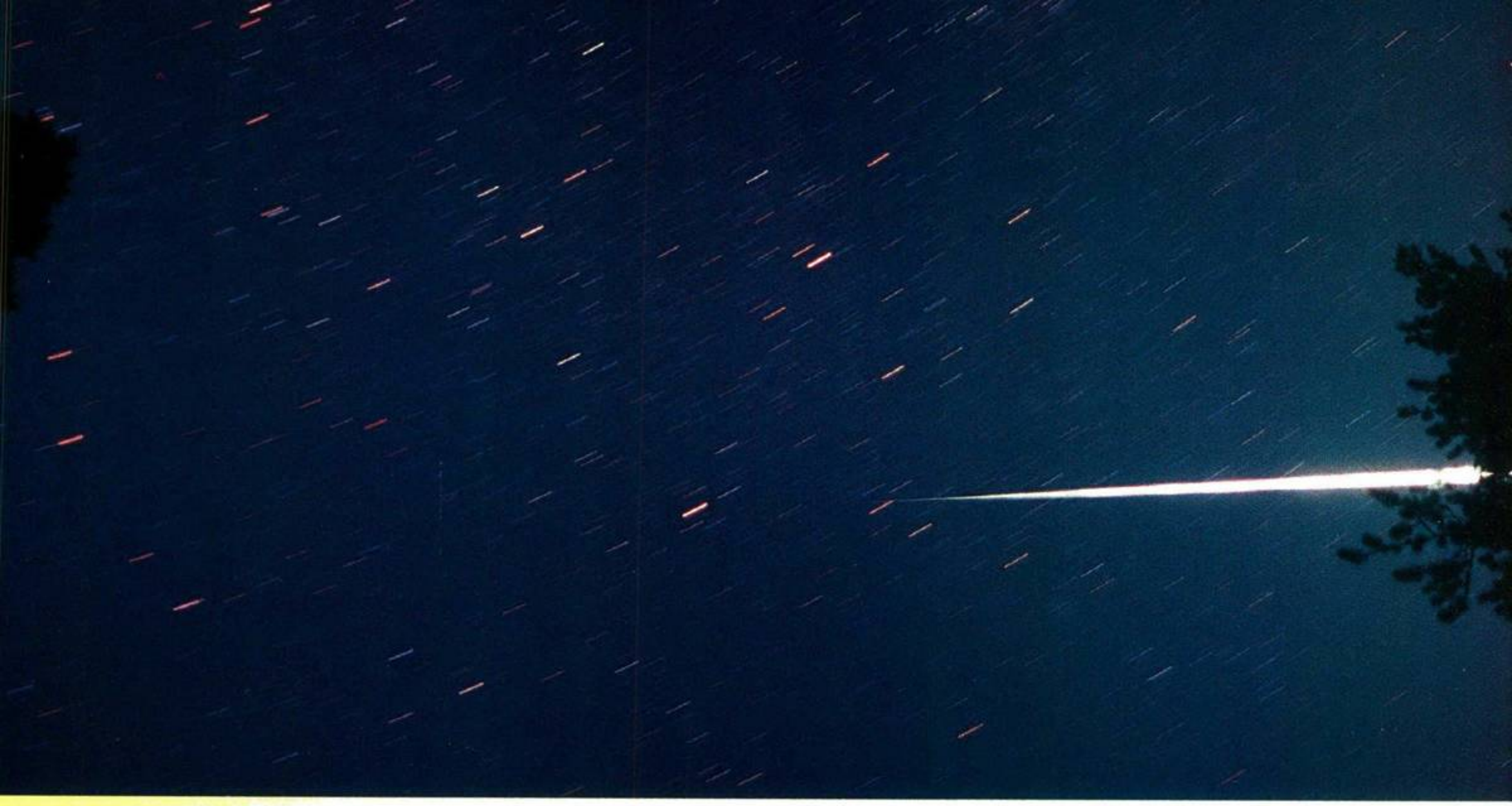
A Bright Perseid Streaks Past Altair
by Michael Kobusch
(30mm f/3.5 fisheye lens, Ektachrome 200 film, 60-minute exposure taken August 11, 1993)

Northern Hemisphere event. Hollenbach always uses slide film. He feels that a bad slide is always better than a mediocre print.

O'Brine, on the other hand, uses print film because he develops it himself and feels he has more control over the results. O'Brine's attempts at using slide film have yielded inferior results to those of print films. He has been "very impressed with Kodak Gold (formerly Ultra Gold) and Royal Gold 400 films. Both offer fine grain (for medium speed film), good color balance, and very low reciprocity failure. This is terrific stuff! Add to the fact that this film is available everywhere and you have an ideal color film for all forms of astrophotography."

Keep in mind that with Kodak Gold/Royal Gold 400 at a reasonably dark site, you will be limited to an exposure of less than 15 minutes at f/2.8 before sky fog sets in. O'Brine has also compared this film to Kodak Royal Gold 1000 and found, remarkably, that Royal Gold 1000 is not as good at capturing faint targets with exposures over a couple of minutes.

For his print film, Emerson prefers black-and-white T-Max 3200. He gets good results using the D-19 developing method by overdeveloping two minutes longer than recommended for maximum sensitivity. If you're using professional processing, he suggests telling the processor to push the film to ISO 6400. As for color, Emerson prefers slides. Ektachrome 800/1600 is his favorite. "It's a more expensive, professional film. I can shoot at ISO 1600 and push it to ISO 4800. I get nice results pushing to ISO 3200." Emerson uses this film for comets, aurorae, and meteors. He



A Brilliant Perseid Fireball
by Scott McAfee
(taken July 27, 1992)

advises against hypering film for meteors.

Palermiti believes slide film works better on faint objects than print film. "If you're using print film and it isn't developed correctly, you lose fainter objects." He too, likes the Ektachrome series including 400, 800, and 1600. "If you've got the shutter wide open and are doing a long exposure, you'll lose background with 1600 speed film. If using 1600, go out into the country where there are no lights because the 1600 will pick up the city lights."

A Falling Perseid Breaks Apart
by Frances Gauger
(taken August 11, 1983)

Practice Makes Not Quite Perfect

Whichever film you choose, the key word is practice. Don't wait for the big event and expect to get good results. Get used to photographing the night sky trying different films. Wetherill suggests bracketing exposures at several ½-stop intervals down from wide-open. "Many lenses won't give sharp pinpoints when used full open, so test the lens and then use the most wide-open setting that yields good images." He advises taping the f/stop setting and the focus so you don't find that "things got bumped in the dark." Emerson adds, "Don't forget to take notes on your film speed, type, and exposure timings. Keep an accurate log so you'll know what worked and what didn't. If you can practice at the site you'll be using for the Perseids, so much the better."

After settling on a film, you're ready to venture out and try some meteor photography. Don't forget a strong, sturdy tripod. If it won't hold the camera still, you'll have more than stars trailing in your pictures.

However, perhaps you don't want stars trailing in your pictures and would prefer pinpoint star images. Whichever your preference, it's time to consider exposure times and techniques. Palermiti takes many short exposures. He shoots 60-second exposures with the camera wide open, one right after the other, for several hours. "You'll use lots of film this way

An Exploding Meteor in Perseus
by Michael S. Weber
(24mm lens at f/2, Fuji Super HG 1600 film, 2 ½-minute exposure)

Looking For More of a Challenge?

Gary Emerson has issued a challenge. Some meteor observers believe that at times you can photograph the comet's cloud of debris as long as the radiant is in the field. If you have a solid tracking mount, go to a good, dark site and expose your photos for at least 10 minutes. If, after processing the film you think you've got the cloud, send your results to the E.E. Barnard Observatory at 34226 Gap Road, Golden, CO 80403. The telephone number is 303-642-3361.

but light pollution will be under control and your stars will be pinpoints." It seems you would also have a great chance of success. From a bright sky, Emerson likes to expose for 30 to 60 seconds, using an f/2 lens and push-processing the film. With a dark sky and the same equipment, he'll shoot for 8 to 10 minutes.

For nice star trail pictures, Palermiti suggests exposing for 15 to 30 minutes, and stopping the exposure immediately after you see a bright meteor go through the field of view. This requires a dark sky site. You might try stopping down the camera to f/4 or f/5.4, which will reduce background light, allowing you to increase your exposure. Again, log your times. If possible, try making the first frame on each roll a normal snapshot so your processing lab knows where the frame-breaks are. Many astrophotographers have spent hours painstakingly exposing their shots only to have the lab cut their pictures in half because it can't tell where the sky image begins and ends. At the least, be sure to tell the lab that your pictures are night pictures.

Each of the veteran skyshooters I talked with agrees that meteor photography works best after midnight. Earth then turns head-on into the meteor cloud and you will get the greatest number of meteors after that time.

A Perseid Crosses Andromeda
by Barry E. Levin
(35mm lens at f/2, Ektar 1000 film, 45-second exposure taken August 12, 1993)

Where to Aim?

Where do you aim the camera? Once again, this depends on the desired result. Aiming the camera directly at the radiant, the point at which the meteors appear to come from, provides a chance of getting "head-on" meteors. These appear as bright, sometimes almost star-like short streaks. If you're after meteor trails, aim about 30° away from the radiant. The radiant lies at right ascension 3h04m, declination 58°.

A Perseid Grazes the Pleiades
by John A. Volk
(105mm lens at f/2.4, Fuji Super HG 400 film, 40-minute exposure taken August 12, 1994)

The Perseid peak varies sometimes by several hours, and activity will increase nightly, as mentioned, after midnight. So the best results may come after midnight, on the morning of Monday the 12th. The radiant rises from low in the northeast to high in the east as the night wanes, and on August 12 it lies a short distance northeast of the Double Cluster in Perseus.

Ultimately, the peak day should yield the most intense display of meteors, perhaps more than one per minute. A day on either side will work also, though the numbers of meteors may be down anywhere from 1/10 to 1/2 of those visible on peak night. Be prepared, and when you see that first meteor streak across the sky, go ahead — make a wish! ☐

Patti A. Kurtz is assistant editor of this magazine. She is gradually getting used to living in Wisconsin. Wait until next winter!

SKY ALMANAC

Jupiter climbs in the east after sunset as elusive Mercury twinkles low in the west. Predawn planets Mars and Venus share Perseid meteors with an old crescent Moon.

by Martin Ratcliffe

Highlights
by Rick Shaffer

Date	Event
6	**First Views:** Morning's Last Quarter Moon ....(p. 61)
7	Nausikaa in the Seagoat ..(p. 65)
8	Morning Journeys of an Old Moon ..(p. 64)
12	A Banner Year for the Perseids ..(p. 64)
all month:	Hale-Bopp Hails the Unaided Eye ....(p. 62) **Observer's Challenge:** Summer's Dark Nebulae ....(p. 63) Nausikaa in the Seagoat ....(p. 65)

Skywatchers look forward to August for its warm weather and stunning skies. In addition, the wonderful Tears of St. Lawrence, popularly known as the Perseid meteor shower, fall from the heavens. This year is very favorable for the shower, which peaks on the morning of August 12 with nary a problem posed by a Moon two days before new. Watching up to 100 streaks of light play each hour against the summer Milky Way's glowing swath keeps sky enthusiasts coming back to the Perseid meteor shower year after year.

An August night under shooting stars begins with the Sun's passage from our sky at sunset. A darkening eastern sky beckons nightfall and the gem-like 1st-magnitude stars of summer emerge from the azure sky. Jupiter joins the dazzling array, low in the southeast. Meanwhile another bright planet, seemingly as fleeting as a summer meteor, appears through evening twilight low in the west during August. It's the planet **Mercury**, whose evening appearances are often difficult to see.

Mercury is the innermost planet in the solar system and orbits in a remarkably short period of 88 days. It never reaches any great angular distance from the Sun, so when visible it always lies in a twilight sky.

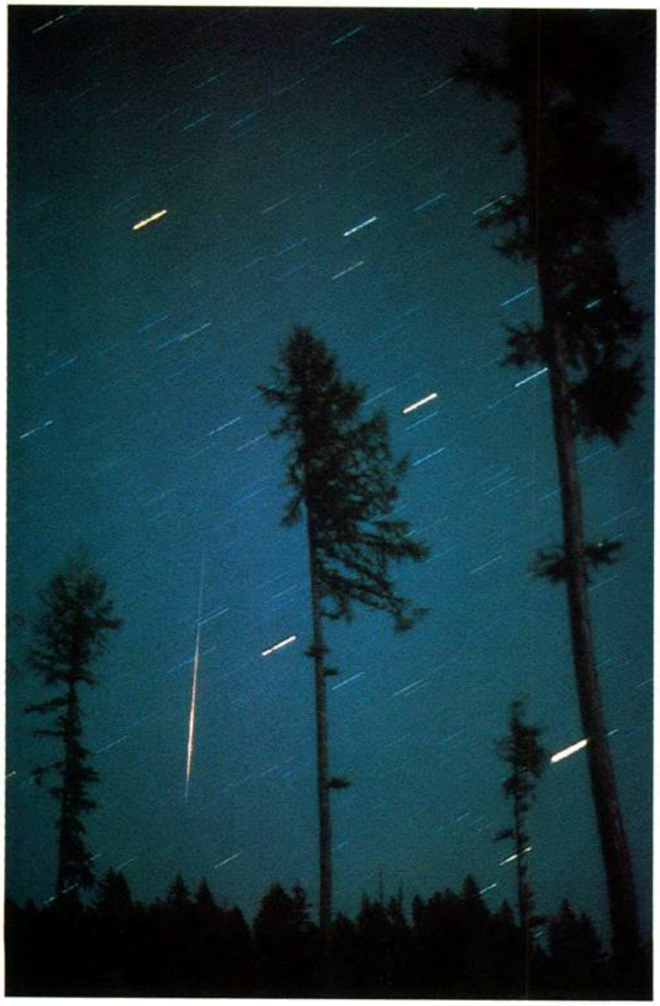
During evening apparitions the tiny planet moves away from the Sun toward darker skies but decreases in brightness, making it harder to see. This is illustrated by the half-magnitude drop in Mercury's brightness as it approaches greatest elongation on August 21. By that time it will be 27° east of the Sun.

On August 1 watch the darkening western sky for a close conjunction of Mercury and Regulus. Mercury shines brighter, at magnitude –0.3, only half a degree north-northeast of 1st-magnitude Regulus, one of the four royal stars of ancient Persia.

The royal stars included Aldebaran, Antares, and Fomalhaut, spaced roughly six hours apart in right ascension. Ancient Persians, in what is today Iran, considered these stars to be the Four Guardians of the Heavens.

Following Mercury and Leo toward the western horizon are two bright stars hard to miss. High in the west glows Arcturus, fourth-brightest star in the sky at magnitude –0.04, and 1st-magnitude Spica, below and to the left of Arcturus.

Arcturus looks very bright for two reasons. First, it lies a mere 36 light-years away in the constellation Bootes the Herdsman. Second, Arcturus is an orange-colored star 27 times the diameter of our Sun. If it were placed where the Sun is, the star's seething mass would extend ⅓ the way



D. Anderson

UP TO 100 METEORS AN HOUR streak from the sky during the annual Perseid meteor shower. This year's Perseids peak on the morning of August 12, when all the Moon can muster is a waning crescent two days before new.

AUGUST

1 Mercury passes 0.5° north of Regulus, 6 a.m. EDT

3 The Moon passes 3° north of Saturn, 9 a.m. EDT

6 Last quarter Moon is at 1:25 a.m. EDT
Asteroid Nausikaa is at opposition (page 65)

8 The Moon passes 1.0° north of Aldebaran, 3 a.m. EDT

9 The Moon passes 1.2° south of Venus, midnight EDT

10 The Moon passes 6° south of Mars, 5 p.m. EDT

12 Perseid meteor shower peaks (page 64)
The Moon is at apogee (252,573 miles from Earth), 12:30 p.m. EDT

14 Asteroid Dembowska is at opposition
New Moon is at 3:34 a.m. EDT

16 The Moon passes 0.3° south of Mercury, 2 p.m. EDT

19 Venus is at greatest western elongation (46°), midnight EDT

21 Mercury is at greatest eastern elongation (27°), noon EDT
First quarter Moon is at 11:36 p.m. EDT

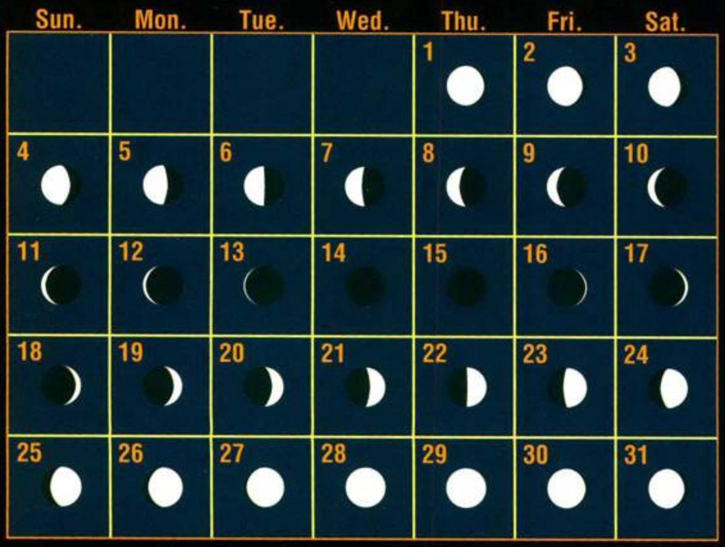
24 The Moon passes 5° north of Jupiter, 6 p.m. EDT

27 The Moon is at perigee (222,933 miles from Earth), 12:54 p.m. EDT

28 Full Moon is at 1:52 p.m. EDT

30 The Moon passes 3° north of Saturn, 5 p.m. EDT

31 Mars passes 6° south of Pollux, 1 p.m. EDT


Sun.
Mon.
Tue.
Wed.
Thu.
Fri.
Sat.
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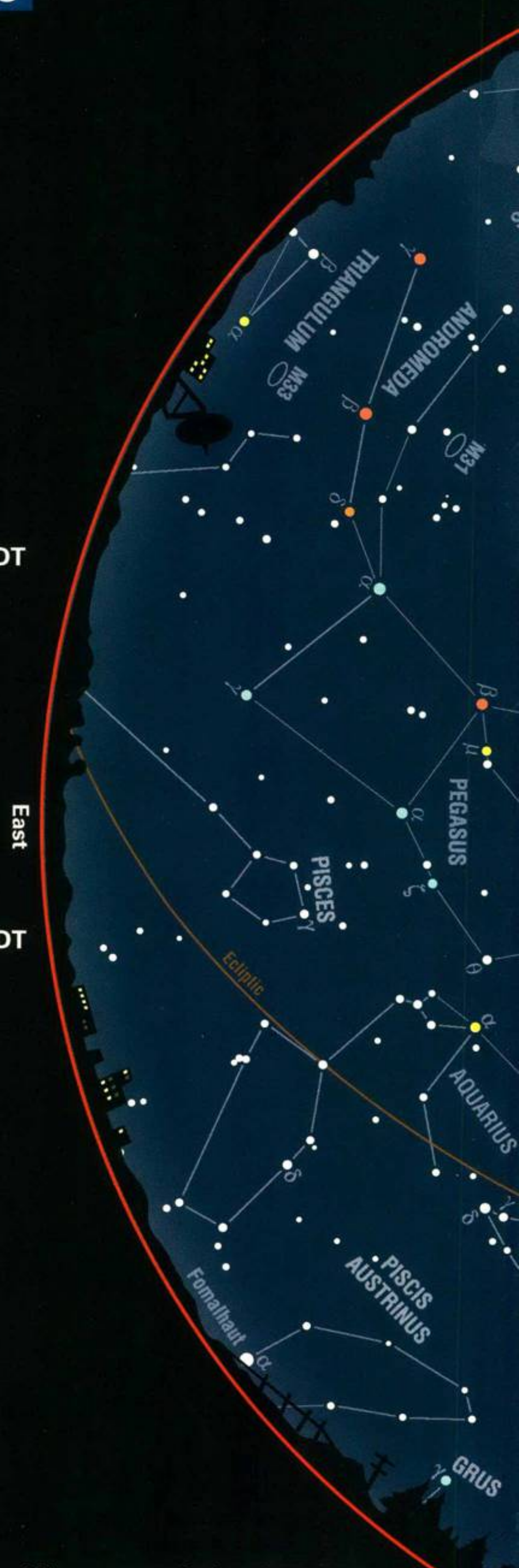
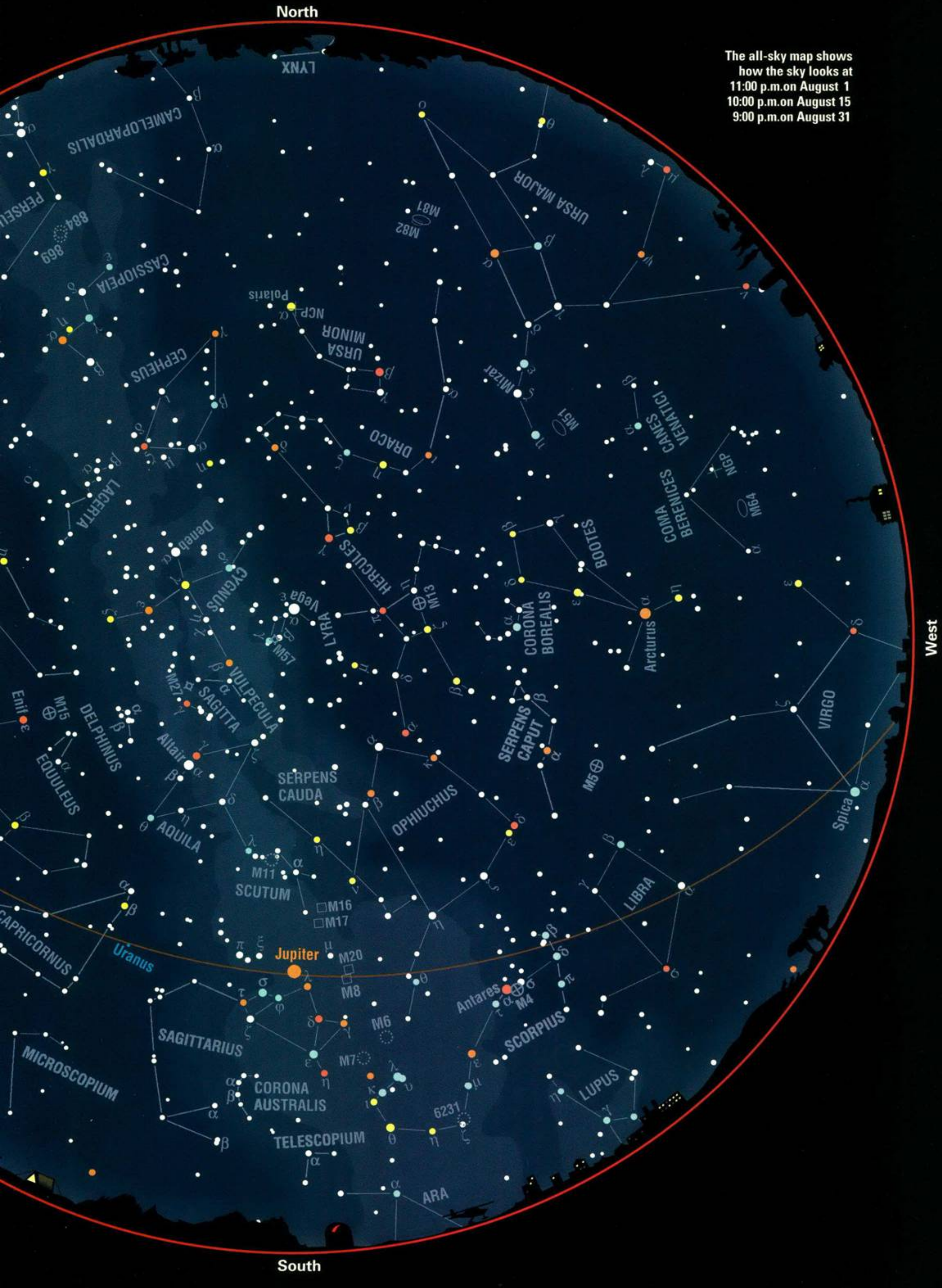
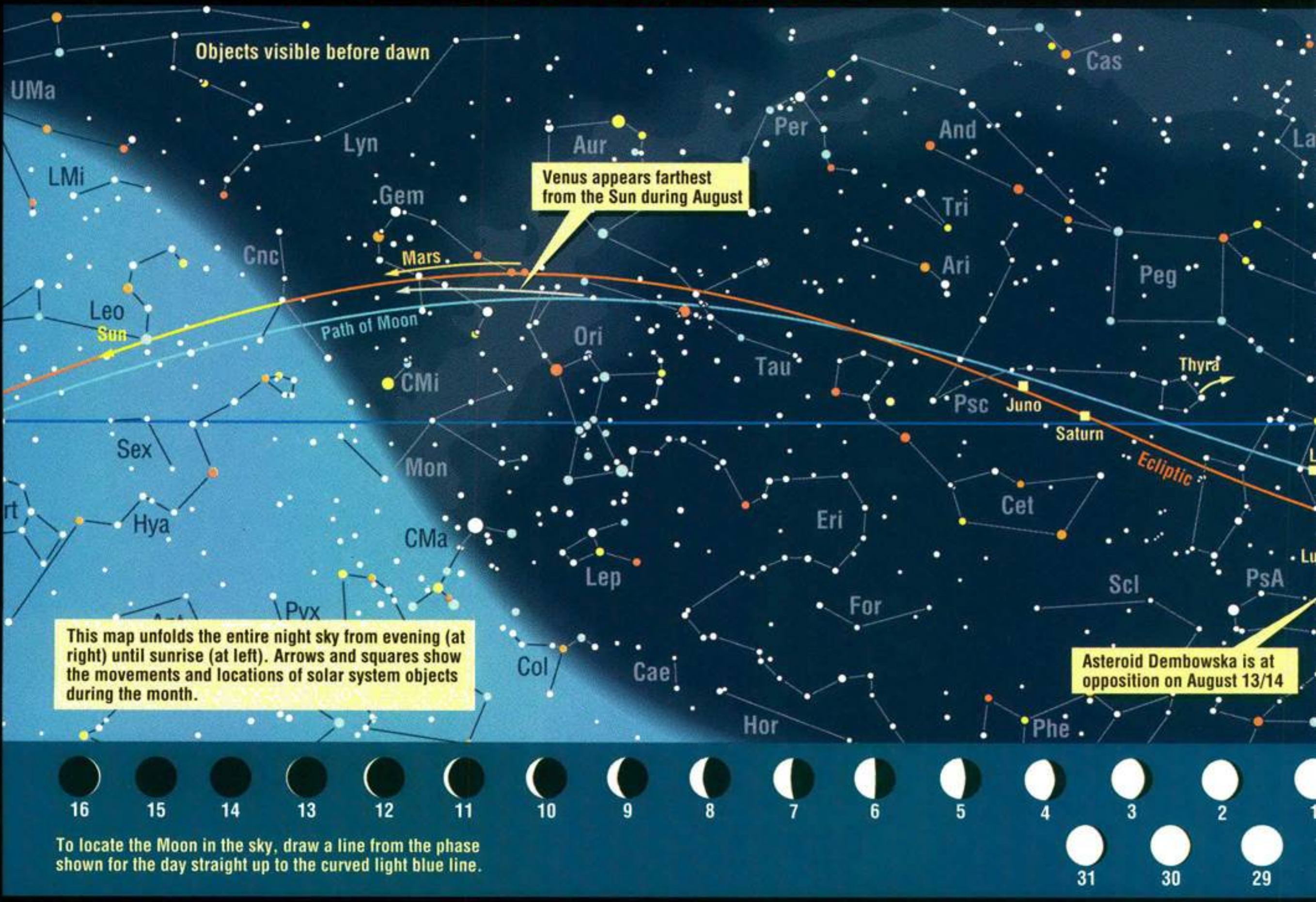

East
TRIANGULUM
M33
ANDROMEDA
M31
PEGASUS
PISCES
Ecliptic
AQUARIUS
PISCIS AUSTRINUS
Fomalhaut
GRUS

This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.


North
South
West
LYNX
CAMELOPARDALIS
PERSEUS
884
869
CASSIOPEIA
CEPHEUS
LACERTA
URSA MAJOR
M81
M82
Polaris
NCP
URSA MINOR
DRACO
Mizar
M51
CANES VENATICI
NGP
COMA BERENICES
M64
BOOTES
Arcturus
CORONA BOREALIS
HERCULES
M13
Deneb
CYGNUS
Vega
LYRA
M57
VULPECULA
M27
SAGITTA
Enif
M15
DELPHINUS
EQUULEUS
Altair
AQUILA
SERPENS CAUDA
OPHIUCHUS
SERPENS CAPUT
M5
VIRGO
Spica
M11
SCUTUM
M16
M17
LIBRA
CAPRICORNUS
Uranus
Jupiter
M20
M8
Antares
M4
SCORPIUS
M6
M7
SAGITTARIUS
MICROSCOPIUM
CORONA AUSTRALIS
LUPUS
6231
TELESCOPIUM
ARA

The all-sky map shows
how the sky looks at
11:00 p.m.on August 1
10:00 p.m.on August 15
9:00 p.m.on August 31

THE PATH OF THE PLANETS


Objects visible before dawn
UMa
LMi
Lyn
Aur
Per
And
Cas
Gem
Venus appears farthest from the Sun during August
Tri
Cnc
Mars
Ari
Peg
Leo
Sun
Path of Moon
Ori
Tau
Thyra
CMi
Psc
Juno
Saturn
Ecliptic
Sex
Mon
Cet
Hya
CMa
Eri
Lep
For
Scl
PsA
Pyx
Col
Cae
Hor
Phe
Asteroid Dembowska is at opposition on August 13/14
16
15
14
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12
11
10
9
8
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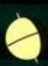
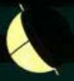
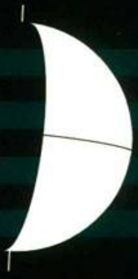
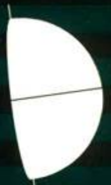
6
5
4
3
2
31
30
29

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.

To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved light blue line.

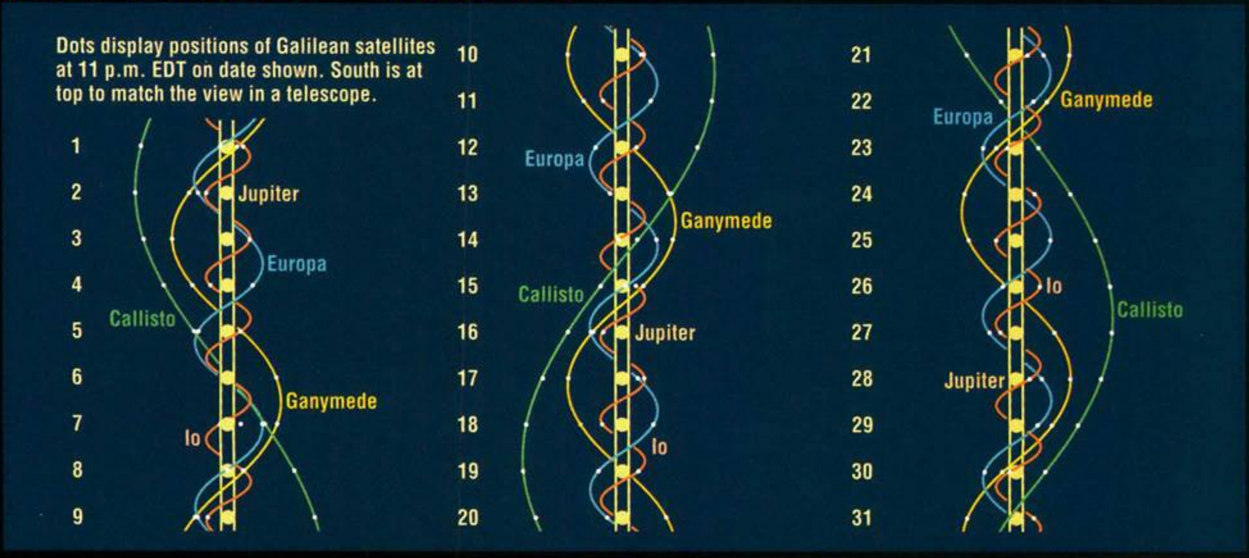
10"

S
W E
N

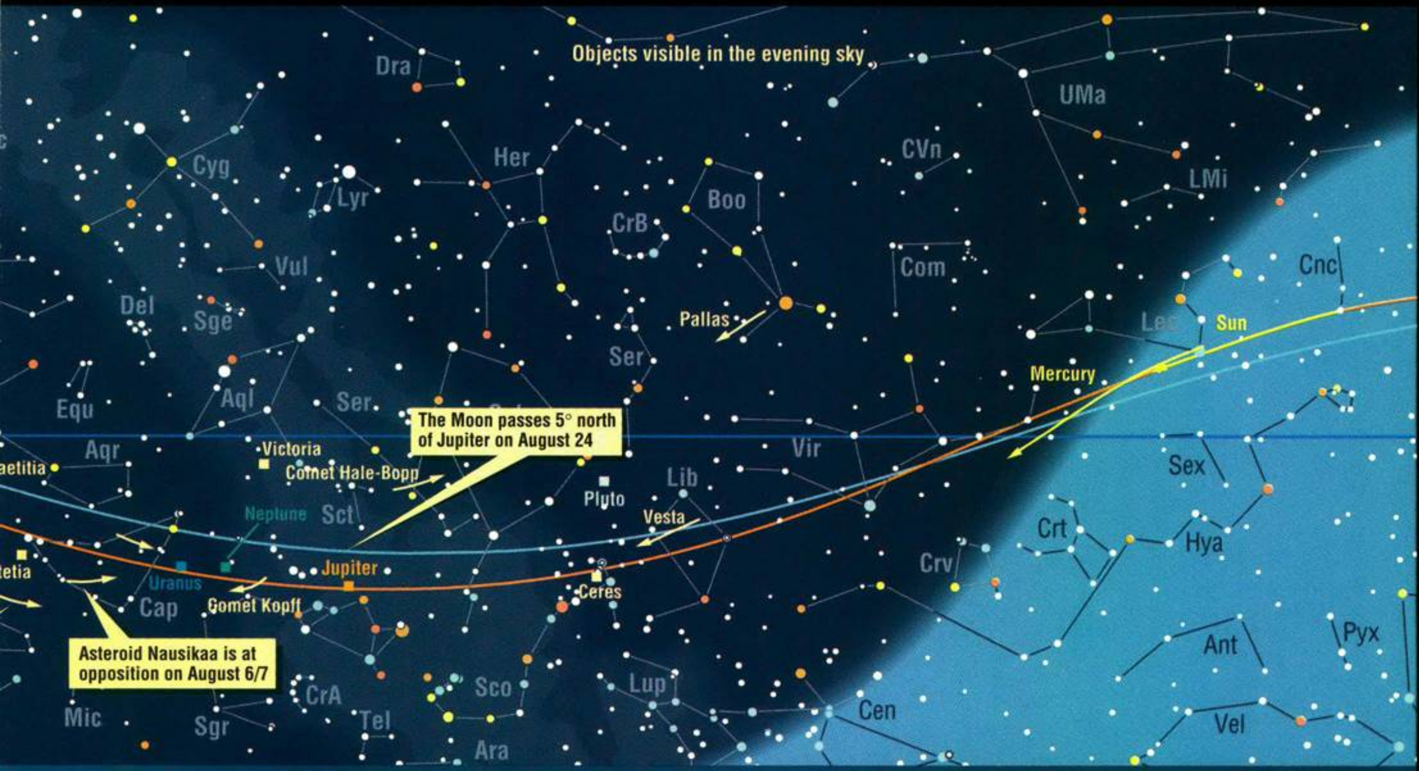





PLANETS	MERCURY	MERCURY	VENUS	VENUS	MARS
Date	August 1	August 31	August 1	August 31	August 15
Magnitude	–0.3	0.7	–4.4	–4.2	1.5
Angular Size	5.6"	8.6"	29.9"	21.1"	4.3"
Illumination	79%	35%	38%	56%	96%
Distance (AU) from Earth	1.197	0.780	0.559	0.792	2.192
Distance (AU) from Sun	0.422	0.448	0.728	0.724	1.543
Right Ascension (2000.0)	10h05.8m	12h04.3m	5h39.0m	7h35.6m	6h58.9m
Declination (2000.0)	12°48'	–4°20'	18°57'	19°18'	23°24'

JUPITER'S MOONS

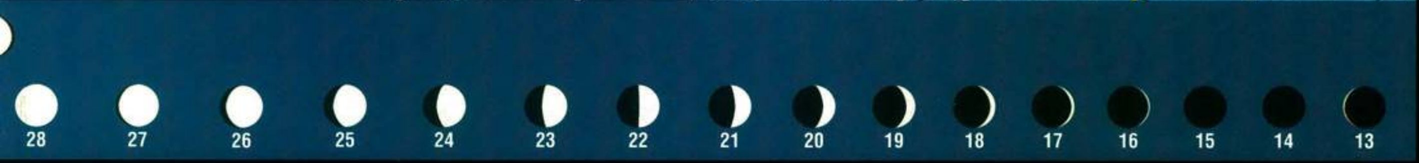


Dots display positions of Galilean satellites at 11 p.m. EDT on date shown. South is at top to match the view in a telescope.


Objects visible in the evening sky
Dra
UMa
CVn
LMi
Cyg
Lyr
Her
Boo
CrB
Cnc
Vul
Com
Del
Sge
Pallas
Leo
Sun
Ser
Mercury
Equ
Aql
Ser
Aqr
Victoria
Vir
Sex
Comet Hale-Bopp
Lib
Pluto
Neptune
Sct
Vesta
Crt
Hya
Jupiter
Crv
Uranus
Ceres
Cap
Comet Kopff
Ant
Pyx
Sco
Lup
CrA
Cen
Mic
Sgr
Tel
Vel
Ara

The Moon passes 5° north of Jupiter on August 24

Asteroid Nausikaa is at opposition on August 6/7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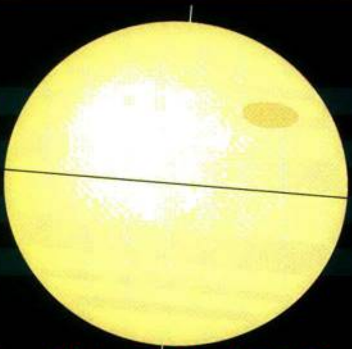
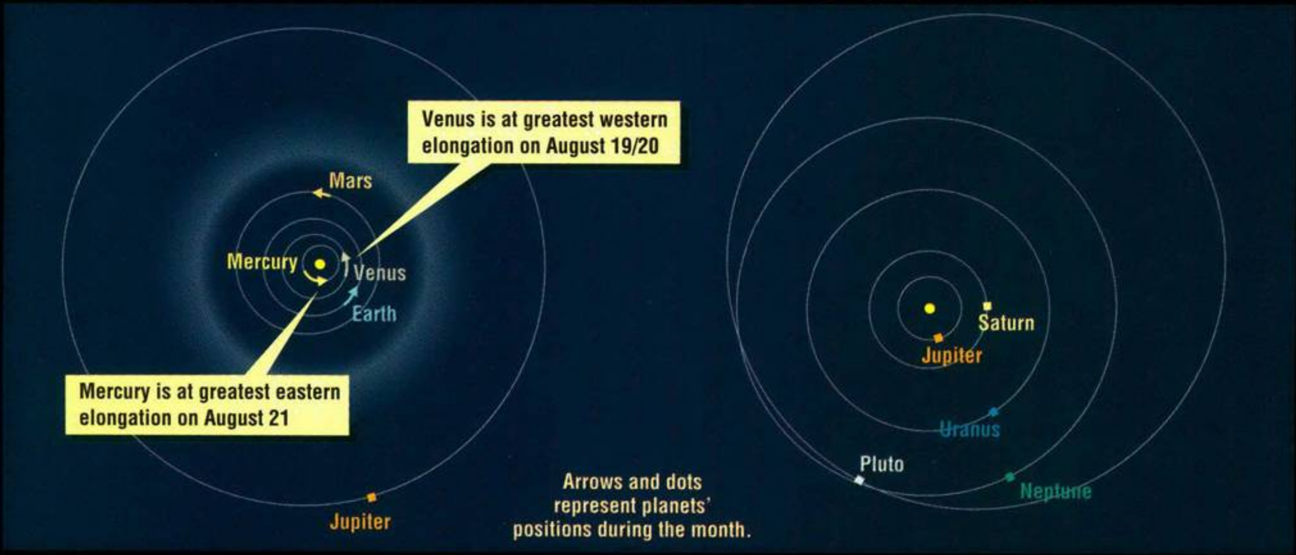


JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
August 15	August 15	August 15	August 15	August 15
−2.6	0.6	5.7	7.9	13.7
44.7"	19.0"	3.7"	2.3"	0.1"
100%	100%	100%	100%	100%
4.412	8.761	18.828	29.252	29.767
5.188	9.511	19.778	30.160	29.920
18h36.9m	0h29.1m	20h17.0m	19h50.3m	16h03.7m
−23°19'	0°24'	−20°21'	−20°32'	−7°32'

THE PLANETS IN THEIR ORBITS


Mars
Mercury
Venus
Earth
Jupiter
Saturn
Jupiter
Uranus
Pluto
Neptune

Venus is at greatest western elongation on August 19/20

Mercury is at greatest eastern elongation on August 21

Arrows and dots represent planets' positions during the month.

to the orbit of Mercury, which circles our star from a distance of 58 million kilometers.

Arcturus' bloated surface shines with an orange-red color, in stark contrast to the blue-white hue of Spica. This luminary in nearby Virgo the Maiden is the 16th-brightest star in the sky, and lies 250 light-years away, seven times farther than Arcturus.

Its brightness is due to a high surface temperature. You can see this simply by comparing its color to Arcturus. The white-hot surface of Spica contrasts nicely with the cooler, red-hot surface of Arcturus. The surface temperature of Arcturus is a relatively cool 4700 kelvins (9000 °F) compared to Spica's staggering 25,600 kelvins (45,000 °F).

Three more hot stars dominate the summer evening sky. High overhead at midevening is Vega, fractionally dimmer than Arcturus and part of the Summer Triangle. The triangle's eastern edge is flagged by Deneb, which marks the tail of Cygnus the Swan. Completing the triangle to the south is Altair in Aquila the Eagle. The trio appear white to the naked eye due to their high surface temperatures.

At the opposite end of cross-shaped Cygnus from Deneb lies Albireo, still another stunning example of star-color counterpoint. At magnitude 3, look for it roughly midway between Vega and Altair. Train your telescope on this yellowish-colored star, and a nearby stunning bluish/purple 5th-magnitude star will be revealed.

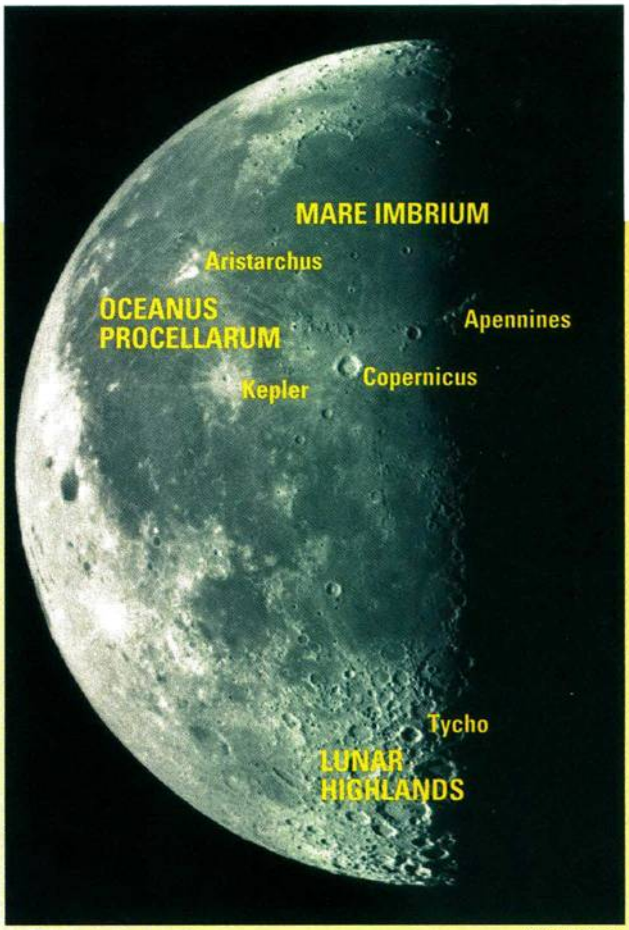
Albireo is a showpiece double star, described by the renowned 19th-century observer Rev. T. W. Webb as "one of the finest in the heavens." In volume II of *Celestial Objects for Common Telescopes*, he recommends defocusing the stars to see the colors "beautifully."

August evenings harbor still other vistas, albeit subtler but nonetheless just as spectacular. For one, the Milky Way runs north to south overhead, though any city or town dweller may never know it.

To see this truly magnificent feature of the summer sky, travel out of town to a dark site far away from city lights. Take along a pair of binoculars to scan the Milky Way from overhead down to the southern horizon.

Dozens of star clusters will dance through the field of view, filling your

First Views:
Morning's Last Quarter Moon



Gérard Therin

A first quarter Moon is perhaps the most observed lunar phase because it's available for viewing pleasure in the early evening. The third quarter Moon, however, is just as rewarding if you stay up late (or get up early) to view it.

Here's a taste of what's visible with the unaided eye.

Compared to what we see at first quarter, most of the last quarter Moon's face is covered with vast plains of solidified lava called *maria*. This Latin word for seas is a holdover from when early observers thought these plains were actually oceans.

North of the equator is Mare Imbrium, while sprawling to the west is Oceanus Procellarum. Only an area north of the south pole, a region called the lunar highlands, seems rough with craters. The highlands look decidedly white to the naked eye, as compared to the gunmetal gray of maria.

Now let's see what the phase holds for observers armed with a pair of binoculars. Even a relatively inexpensive pair reveals mountains and craters.

The Apennine Mountains ring the eastern edge of Mare Imbrium. This range marks the top of an ancient crater rim created when a giant asteroid slammed into the Moon more than three billion years ago. The yawning crater flooded with lava that welled though cracks caused by the impact. That magma cooled into what we see today as Mare Imbrium.

Western Imbrium and neighboring Oceanus Procellarum hold prominent craters like Aristarchus, Kepler, and Copernicus. They sport a splashy network of rays, stuff kicked out upon the surrounding plains when impacts made each crater. Another crater, Tycho, and its web of rays dominate the lunar highlands. Tycho's rays best reveal themselves between Full Moon and third quarter, which is one good reason to begin observing the Moon even a week before third quarter. The Sun's changing angle will reveal new features while masking still others. — *Rick Shaffer* eyes with stunning sights. Stop at the occasional cluster or nebula. With names like Wild Duck, Trifid, and Eagle, these fine objects will instill wonder as you gaze through one of the arms of our spiral galaxy, and toward its center into the region of Sagittarius.

The main stars of Sagittarius look like a teapot. A trapezium-shaped group of stars is the main body of the teapot. Two associated triangles, one on the upper side and another on the right or western side of the trapezium, respectively represent the lid and spout of the teapot. The handle is marked by a mini-trapezium on the eastern side.

Eighteenth-century comet hunter Charles Messier, in his catalog of objects that looked suspiciously like his desired quarry, listed no fewer than 15 objects within Sagittarius.

To find one of these objects cataloged by Messier, look carefully just over a couple of degrees northeast of the star that marks the top of the teapot's lid, Lambda (λ) Sagittarii, for a fuzzy 6th-magnitude "star." This is M22, a star-studded globular cluster lying 10,000 light-years away and containing 70,000 stars — the 22nd object in Mr. Messier's listing.

A 4-inch scope will partially resolve this cluster, but in binoculars it does indeed look like one of Messier's wayward comets. As if to underscore coincidental appearances, a real comet called Hale-Bopp lurks north of Sagittarius among the stars of Serpens Cauda and Ophiuchus, hovering around the limit of naked-eye brightness.

Less than 2° away from M22 during August is a brilliant object that lies a mere 37 light-minutes away, or 656 million kilometers. Shining at magnitude –2.6, the giant planet **Jupiter** dominates the southern sky in Sagittarius. It lies due south by late evening on August 1 and transits two hours earlier by the 31st.

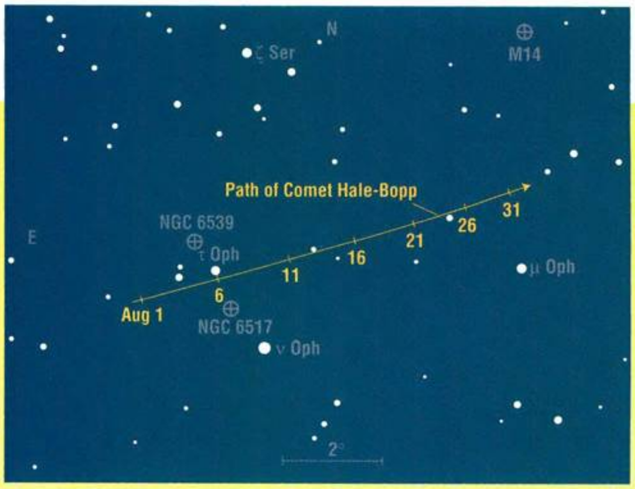
A waxing Moon, four days from full, passes just 5° north of Jupiter on August 24. Jupiter is a month past opposition, so it is clear of the southeastern horizon by nightfall and perfectly placed for evening viewing.

A day after passing north of Jupiter, the Moon passes a little over 4° north of dimly lit **Neptune** in eastern Sagittarius. This month Neptune's tiny disk struggles to reach 8th magnitude and is best seen in telescopes larger than 6 inches.

Neptune's nearer cousin, **Uranus**, is an easier target at magnitude 5.7, which makes it technically a naked-eye object in western Capricornus.

While in this area of the sky, scan midway between the two planets and 1 ½° south for the dim globular cluster, M75. At about 100,000 light-years away, it

Hale-Bopp Hails the Unaided Eye



As I write this in late March, Comet Hyakutake is breaking a 20-year comet drought as it streaks through the northern sky. It's wonderful, but jumbo-sized comet Hale-Bopp could be even better.

As if to remind us of this possibility, Hale-Bopp becomes visible to the unaided eye during August under dark skies. Since it is still more than 3.0 AU from the Sun and more than seven months from perihelion passage, this milestone does bode well for next spring's apparition.

The comet lingers in southern Serpens Cauda as August begins. As the month progresses, Hale-Bopp settles into Ophiuchus for an autumn stay. Although the comet's achieving naked-eye brilliance is a big deal for Hale-Bopp enthusiasts, one opportunity for telescopic observers and astrophotographers may steal the show.

On August 6 Hale-Bopp passes between two globular clusters, NGC 6517 (magnitude 10.3, 4.3' in size) and NGC 6539 (9.8; 6.9'). To make this evening more attractive, the comet passes just ¼° south of the 5.2-magnitude double star Tau (τ) Ophiuchi.

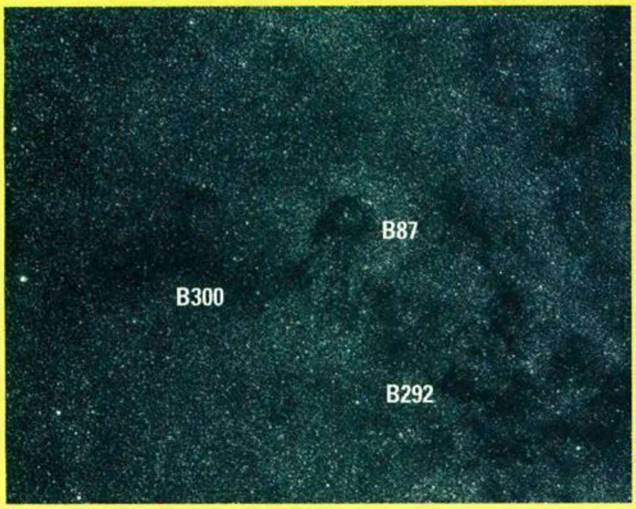
Photograph this passage with a 600mm telephoto lens on a 35mm camera. First inspect the comet with binoculars to determine the length of its tail, and then properly frame the comet, its tail, and the globulars. Piggyback the camera on a motor-driven equatorial mount that follows the sky's motion. With the lens stopped down one f/stop, expose ISO 1000 film for between five and 20 minutes, perhaps in five-minute increments.

Photography aside, don't fail to keep tabs on Hale-Bopp as August unfolds. Remember, this comet features a 20- to 30-km-wide nucleus and an envelope of dust that's possibly 2.5 million km across, making it one of the largest cometary bodies to ever invade the inner solar system. Consequently, it's likely to be quite active this month.

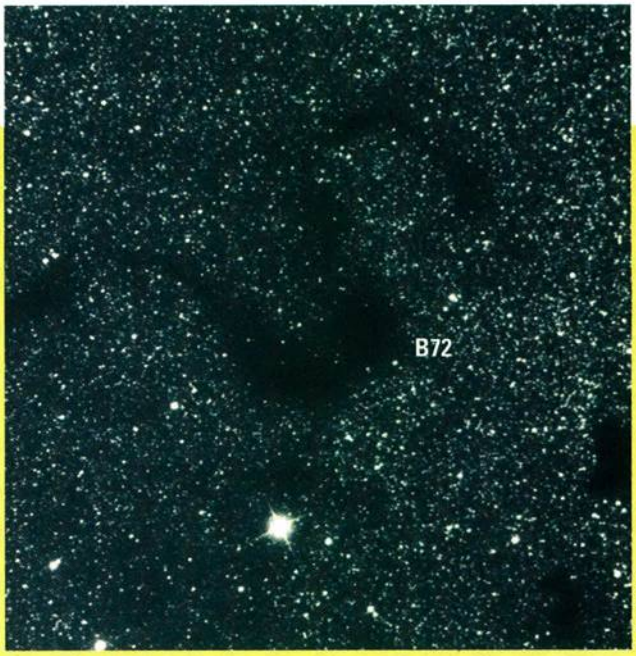
Begin observing it with binoculars or a low-power telescope, looking for detail in the tail. Then concentrate on the coma and nuclear region with higher power through a telescope.

Are there any jets of material "boiling" off Comet Hale-Bopp's central coma yet? — *R. S.*

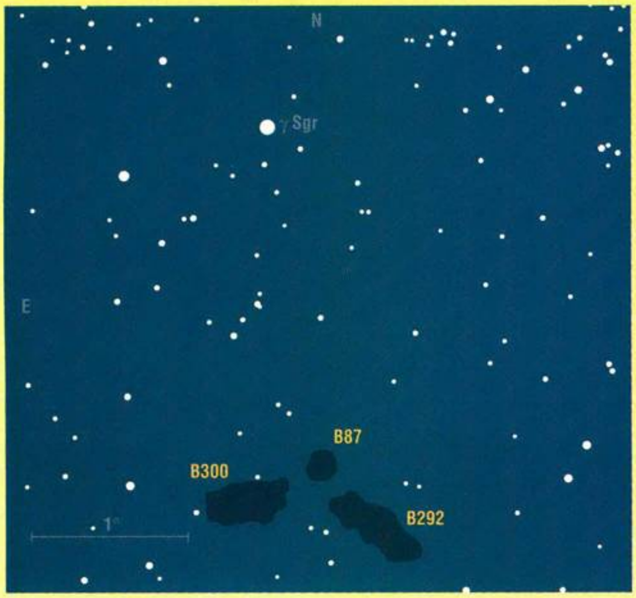
Observer's Challenge: Summer's Dark Nebulae

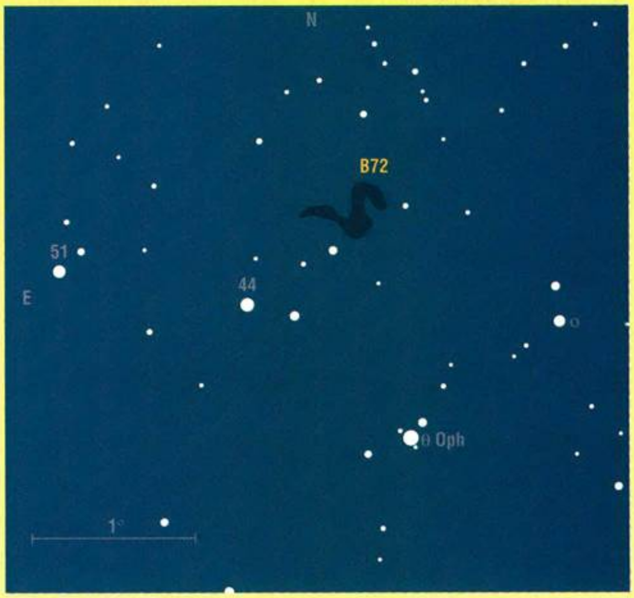


Brad Wallis



J. C. Mirtle





Writing about something that's mostly dust would seem to describe a political reporter's living. However, it's just me leading you on a tour of some of the most subtle and beautiful objects in the summer sky, the dark nebulae.

Although regions up and down the Milky Way Galaxy are littered with these dust clouds that block background starlight, space only allows me to tell you about four.

My favorite is Barnard 72, a delicate, S-shaped object a little more than half a degree across. You'll find it a bit more than 1° north of Theta (θ) Ophiuchi. I've often placed B72 just out of the field in a 20-inch telescope and let Earth's motion slowly pan the object into view. It's a peaceful, unhurried way to glean B72's subtle beauty.

Two more favorites, B92 and B93 in nearby Sagittarius, are clouds that lie superimposed on the amorphous star cloud M24. If you wish to star-hop, you'll find this pair of dark nebulae 1 ½° east-northeast of Gamma (γ) Sagittarii. Both objects fit nicely into a 1° field.

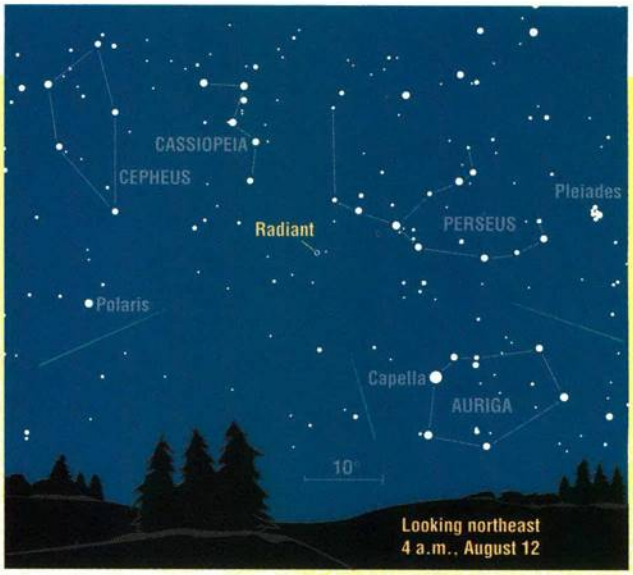
Use Gamma Sagittarii to also find the last of this month's elusive dark nebulae. It's B87, just 2° south of and a bit west of Gamma. This object is probably the most difficult of the four I've mentioned.

If B87 shows up well, try going for B300 and B292, two nebulae that are better than three times the size of B87 and lie barely to the southeast and southwest, respectively.

As you might surmise, seeing dark nebulae involves going to a site free of light pollution. However, doing so on a humid night will spoil your view. Pick a night when there is little water vapor or dust in the air.

Also, let your eyes adapt to the dark for at least 30 minutes before attempting dark nebulae. Finally, use low power to view them. I've often found that 10x70 or 11x80 binoculars show dark nebulae well. — *R. S.*

A Banner Year for the Perseids


CASSIOPEIA
CEPHEUS
Radiant
PERSEUS
Pleiades
Polaris
Capella
AURIGA
10°

Looking northeast
4 a.m., August 12

This year's Perseid meteor shower peak occurs near New Moon on August 12, ensuring that observers will be able to watch the shower's four-day duration with little or no interference from pesky moonlight. We'll only have to deal with light pollution, which is nothing a drive into the country can't cure.

Although the Geminid meteor shower in December annually produces more meteors per hour, more people want to watch the Perseids.

Why? For one, because it's downright cold in December. But there's one other reason. The Perseid shower seems to be the Nolan Ryan of meteor showers. Those of you who follow baseball know that Mr. Ryan pitched in the Major Leagues for 26 years, and his approximately 100-mph fastball seemed to be just as fast in Year 26 as it was in Year 1. Not only was he fast, he was fast for a long time!

So it is with the Perseids. The shower's been associated with the constellation Perseus and the month of August for as far back as 36 B.C. And at an average speed of 60 km/second, the Perseids are also among the sky's fastest-moving meteors.

To observe the Perseids, face northeast, where Perseus rises on August nights. Although the meteors can stream across any direction through the sky, each will point back to one point in this constellation called the shower's radiant.

As the night hours merge into predawn, expect meteor activity to pick up as the morning side of Earth plows head-on into the meteoroids. Expect to see up to 100 meteors an hour on the morning of August 12.

The Perseids average magnitude 2.3 in brightness; many of them are considerably brighter. Because they're so fast, nearly 50% of them show persistent smoke trains best admired through binoculars.

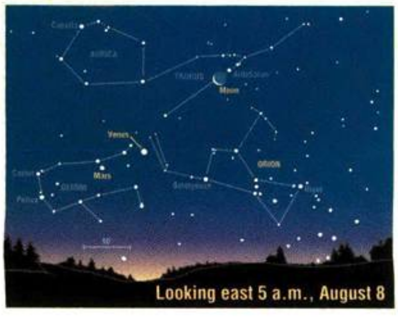
Perseid meteors are so swift because they're going around the Sun in a reverse direction from Earth. Their orbital velocity in one direction combines with Earth's orbital speed in the opposite direction. — *R. S.*

Morning Journeys of an Old Moon

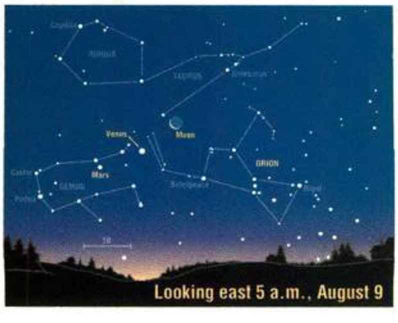
On the mornings of August 8 and 9 the old Moon, a waning crescent, passes just north of Orion the Hunter on its way to a nice conjunction with Mars and Venus on the morning of the 10th. This gives us all an excuse to take the season's first look at M42, the magnificent Orion Nebula. It's also a prime chance to preview the stars of winter as they make a slow crawl away from the Sun's glare into the predawn night sky.

On the 8th, the Moon lies northwest of Orion, having just passed through the Hyades only hours earlier for European skywatchers. Observers in the area of Canada's Hudson Bay will see Aldebaran occulted by the Moon earlier in the evening. Anyone interested in observing this event should check the International Occultation Timing Association's URL at http://www.anomalies.com/iota/splash.htm.

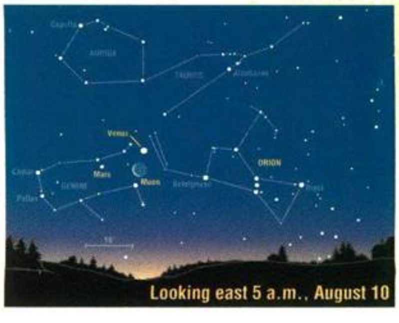
The following morning Luna is directly north of Orion, and by August 10 it's at the feet of Gemini the Twins. On that morning Mars lies 7 ½° to the left of the 26-day-old Moon, while Venus lingers some 4° above. A camera fitted with a lens wider than 50mm should yield wonderful photographs of this scene. Don't forget to grab a view through wide-angle binoculars. Can you see the Moon's maria bathed in Earthshine? — *R. S.*


Capella
AURIGA
TAURUS
Aldebaran
Moon
Venus
Mars
Castor
GEMINI
Pollux
Betelgeuse
ORION
Rigel
10°

Looking east 5 a.m., August 8


Capella
AURIGA
TAURUS
Aldebaran
Moon
Venus
Mars
Castor
GEMINI
Pollux
Betelgeuse
ORION
Rigel
10°

Looking east 5 a.m., August 9


Capella
AURIGA
TAURUS
Aldebaran
Venus
Mars
Moon
Castor
GEMINI
Pollux
Betelgeuse
ORION
Rigel
10°

Looking east 5 a.m., August 10

is the farthest globular in Messier's catalog.

Capricornus also hosts the Moon when it reaches the closest point in its orbit around the Earth on August 27. This makes the following evening's full Moon the third nearest full Moon of 1996.

August's full Moon, also called the Grain or Green Corn Moon, will measure 33' across, a full 3' larger than December's full Moon. Compare their respective sizes by shooting snapshots of both full Moons through a 100- or 200mm lens.

After Jupiter passes the meridian around 10 p.m. in early August with its retinue of fellow gas giant planets, check the eastern horizon for 1st-magnitude **Saturn**, rising near the Cetus/Pisces border.

A telescope shows the illuminated southern face of Saturn's rings as well as the planet's shadow falling across the rings. Saturn begins August by cutting across the corner of Cetus, but finishes the month back in Pisces lying right on the celestial equator.

Once Saturn crosses meridian in the early morning hours, **Venus** sparkles into view low in the east in Gemini, along with faint Mars some 7° east-northeast. On August 10 a crescent Moon joins Venus, gliding a degree south of the second planet from the Sun. Venus reaches its highest point on August 19/20, when it rises more than 3 ½ hours before the Sun.

This brilliant predawn beacon provides a dramatic backdrop for 1996's Perseid meteor shower, which peaks on the morning of August 12. With a new Moon on the 14th, conditions are ideal for this traditionally active shower.

The shower's radiant, a point from which all the meteors appear to emanate, clears the northeastern horizon by midnight.

Although some Perseid meteors flash across the sky before midnight, a greater number fall during the early morning hours. That's when Earth's daily rotation brings us head-on into a stream of particles left behind by Comet Swift-Tuttle in its 130-year orbit around the Sun.

These tiny comet meteoroids, each no bigger than a tiny grain of sand, careen into the Earth's atmosphere at tens of kilometers per second, burning up in tiny flashes of light.

The predawn sky holds still more evidence for a dusty solar system. One to two hours before sunrise, draw an imaginary line from Venus through Mars down to where you think the Sun lies, far below the horizon. This line represents the ecliptic, the plane of our solar system.

If the sky is dark enough, you might glimpse a faint cone of light almost as bright as the Milky Way running up along the ecliptic into Taurus.

This is the zodiacal light. August and September are the best months to view this phenomenon before dawn because the ecliptic is at its highest angle to the horizon.

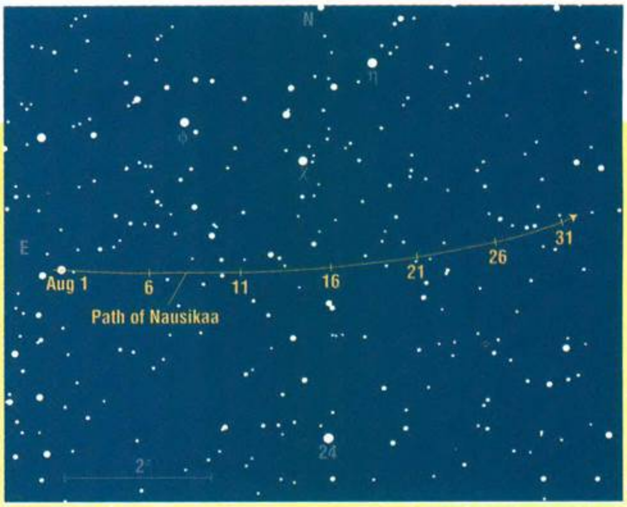
The zodiacal light is sunlight reflecting off fine dust that lies in the plane of our solar system.

In the gathering light leading up to sunrise, shift your gaze about 50° above the eastern horizon to catch the brilliant yellow Capella. A telescope in Cambridge, England, recently used three 16-inch telescopes in unison to simulate a telescope 20 feet across.

This special scope resolved Capella as a double star for the first time. The pair of Sun-like stars were imaged a few days apart to show them orbiting each other in 109 days. Consider how different our sunrise would look with two suns like that! □

Martin Ratcliffe directs the Henry Buhl, Jr., Planetarium in Pittsburgh, Pennsylvania. Rick Shaffer is an engineer and writer living in Arizona.

Nausikaa in the Seagoat



Asteroid 192 Nausikaa reaches opposition on August 7, shining at magnitude 9 as it passes through the stars of Capricornus the Seagoat. This 94-km-wide chunk of rock, discovered in February 1879, is named for the daughter of Alcinous, king of the Phaeacians in Greek mythology.

Nausikaa's route through star-poor Capricornus offers astrophotographers an opportunity to capture the asteroid's motion with a series of piggyback photographs.

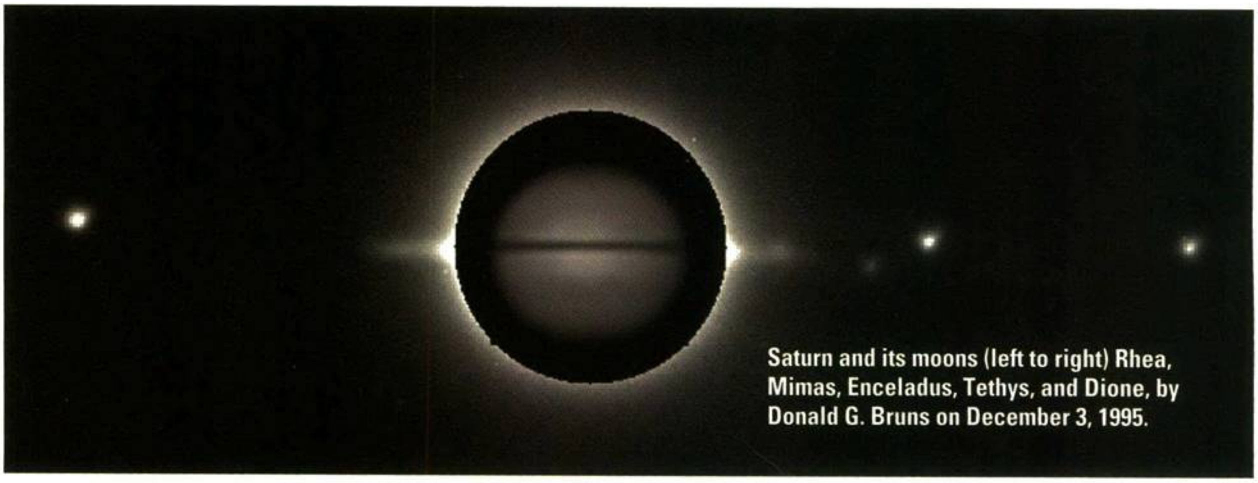
Attach a 35mm camera fitted with a normal (50-55mm) lens to any equatorially driven telescope and make sure all of the Seagoat is framed. Using 400-speed film, take exposures each night of two, four, eight, and 16 minutes at f/2.8.

Start photographing on August 1 and progress in two- or three-day increments into the middle of the month, when the Moon begins to interfere with photography.

Owners of CCD imaging equipment should try taking a series of brightness measurements of Nausikaa over an entire night, at either 15- or 30-minute intervals.

Graph Nausikaa's light intensity with respect to time to see if there's any variation. Do the observations reveal a rotation rate for the asteroid? *Asteroids II*, the latest authority on the subject (University of Arizona Press, 1994), lists a period of 13.6 hours. — *R. S.*

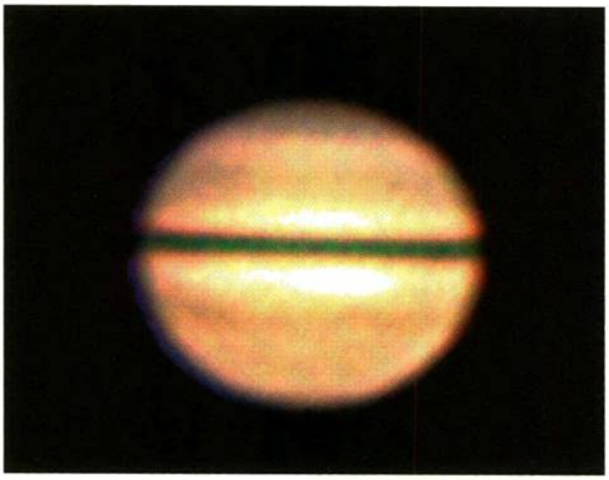
Saturn's Missing Rings

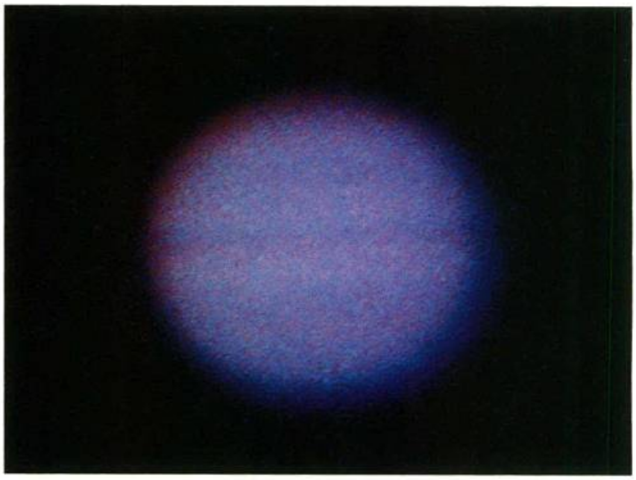


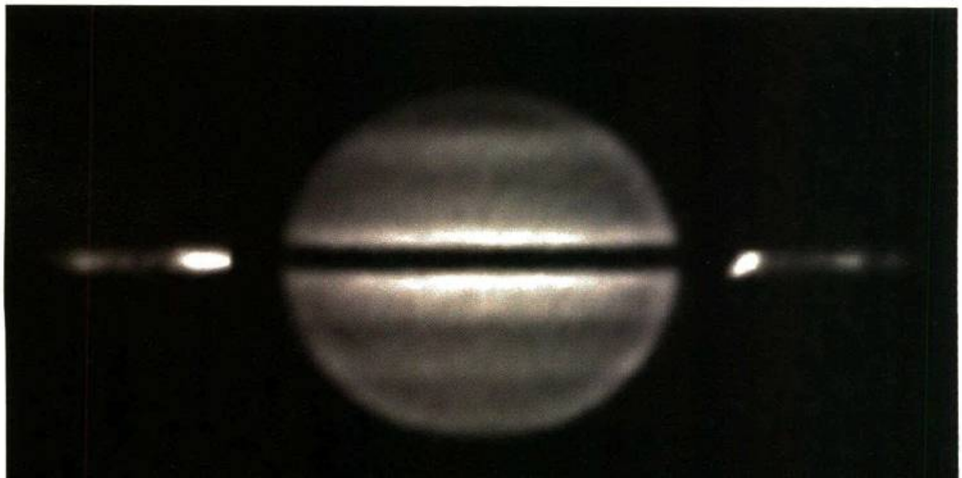
Saturn and its moons (left to right) Rhea, Mimas, Enceladus, Tethys, and Dione, by Donald G. Bruns on December 3, 1995.

With its glorious rings turned edge-on to our line of sight, Saturn last year showed a side of itself unseen in 15 years.

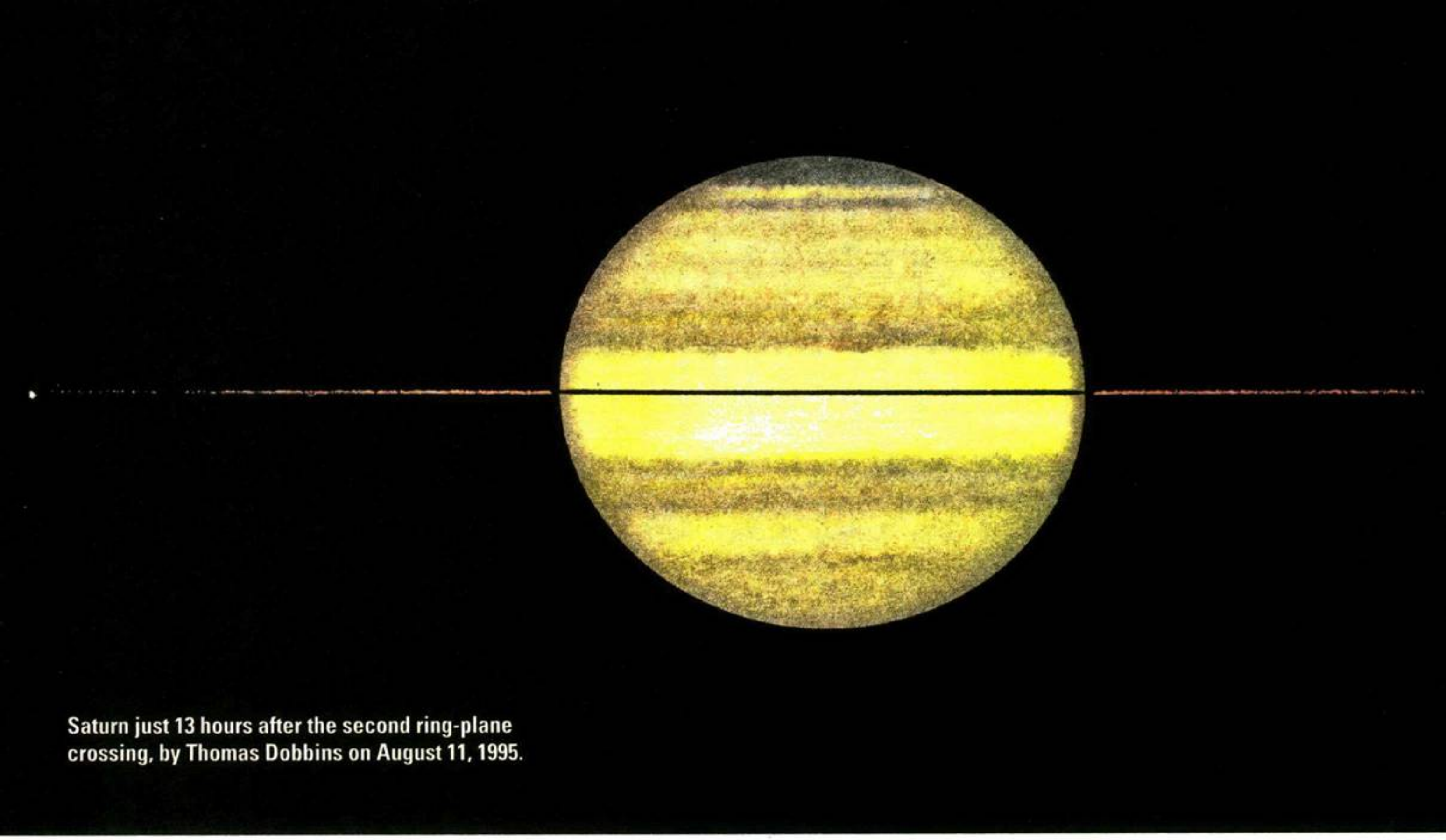
by Richard Talcott







Saturn appears without rings less than a day after the first ring-plane crossing (above), by Donald Parker on May 23, 1995. Saturn at the second ring-plane crossing (above right), by Dan Schechter on August 10, 1995. Saturn and its backlit rings, with the Sun north and Earth south of the ring-plane (right), by Donald Parker on July 4, 1995.



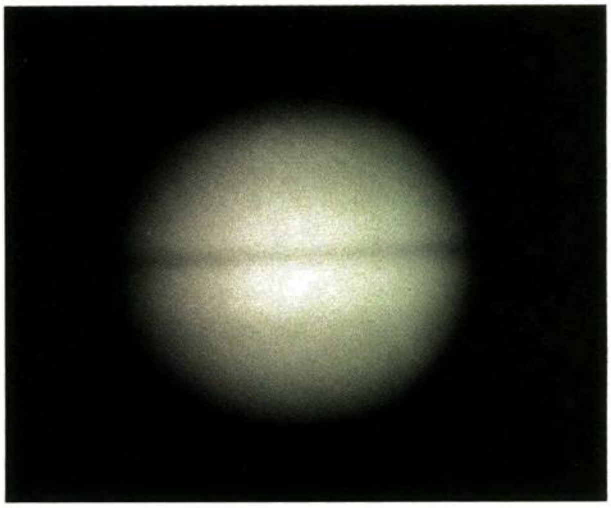
Saturn just 13 hours after the second ring-plane crossing, by Thomas Dobbins on August 11, 1995.

Ask any gathering of backyard observers what's the most beautiful planet, and a majority will quickly reply: "Saturn." So compelling is the telescopic view that many return to Saturn night after night, whether for a long, detailed look or just a quick glance.

But the past year has shown Saturn in a different light. Instead of an intricate set of rings encircling a golden-hued globe (which was overlooked as often as not), the globe itself became the story. In 1995, for the first time since 1980, the Sun and Earth passed through the ring-plane of Saturn. For much of the year, the rings simply disappeared from view in most backyard scopes, and even when they were visible, they appeared razor thin.

But backyard astronomers are an enterprising lot, and many found that Saturn, even without her rings, offered much to see. Many observers concentrated on the planet's previously underappreciated disk. They saw a complex atmosphere displaying alternating bands of light and dark material similar to, albeit subtler than, those typically seen on Jupiter.

Even the nearly edge-on rings weren't totally off-limits. Some people viewed them within days or hours of the ring-plane crossings on May 22 and August 10. Thomas Dobbins used the 36-inch refractor at Lick Observatory to detect tenuous material in the ring-plane just 13 hours after Earth crossed it on August 11. And Donald Parker imaged the ghostly backlit rings on July 4, when Earth lay south and the Sun north of the ring-plane.



Saturn with backlit rings just one day before the second ring-plane crossing, by Thomas Dobbins on August 9, 1995.

Finally, many observers took advantage of the diminished glare from the rings to view Saturn's fainter satellites. At most times, only the bright moons Tethys, Dione, Rhea, and Titan are easy to spot near the planet. Last year, however, the faint inner satellites Mimas and Enceladus came into easier view.

People who enjoy these subtle aspects of Saturn will have to wait for the next ring-plane crossing in 2009. But for those who enjoy seeing Saturn and its rings in all their glory, the ringed planet presents a more pleasing view this summer, and will for the next several years. ☐

Free-form Observing

An observing agenda is all well and good, but don't let it get in the way of discovering the universe.

by Jeff Kanipe

Behold the well-equipped, amateur astronomer: The opening strains of *Also Sprach Zarathustra* come to mind as we approach the high-gloss telescope arrayed with computerized deep-sky finders, electronic tracking systems, digital readouts, and winking LEDs. Strewn across his observing table are star charts, observing guides, sky atlases, catalogs, and various and sundry celestial lists. Clutched in his hand is the "strategy" for tonight's deep-sky foray. No way is this guy getting lost in the universe.

Just once, though, wouldn't it be an adventure to turn off the electronics, put away the charts, tables, and atlases, lose the observing list, and trek across the sky for parts unknown? This is exactly the approach I'd like to suggest for observers, both experienced and inexperienced, one in which you don't go to the sky as much as you let the sky come to you. I call this slightly unorthodox approach, "free-form observing."

A false comet.

Jeffery L. Jones

Begin Anywhere; Go Everywhere

Put in a low-power eyepiece and begin at some point in the sky. It doesn't matter where. Just pick a point. Then make leisurely sweeps — overlapping passes across the sky — as if you're painting. Or, if you prefer, meander in one direction until you reach the horizon then return.

As soon as you're no longer looking for one specific thing but are open to whatever serendipitously presents itself, your eye becomes more sensitive. Star patterns leap out at you. Colors, brightnesses, and contrasts are more apparent. Smudgy clusters, faint nebulae, and suspect galaxies that you might otherwise pass over take on added presence in the eyepiece. And when you do happen to scan across some bright object, your senses, attuned as they are to fainter fare, can be dazzled.

Preston Scott Justis

A bright globular.

It's high summer now and the billowy star clouds of the Milky Way beckon. What awaits us?

A Bright Globular

Using a 13-inch Dob and my trusty 21mm Plössl — a moderate wide-field ocular — I point the telescope toward one of the more intriguing areas in the sky: just north of the bright stars of Sagittarius. The field is burnished with countless stars. But where to? As rich as this part of the sky is, you're bound to run into something no matter which way you go.

I opt to slew eastward but don't get five degrees before a bright globular swims into view. The milky core is highly concentrated and slightly elongated

"The last night was spent Sweeping till

Ivan Dryer

Where to begin?

Kim Zussman

Eye in the sky

southwest to northeast. It seems to swell above the surrounding stars. A small knot of bright stars lies along the northeastern edge of the core. The outer members are well resolved and evenly distributed. A single bright field star lies immediately to the north just beyond the outliers. My first unexpected discovery of the night. An auspicious beginning!

A False Comet and a Surprise

Continuing northeastward, I stumble onto a small, round comet-like object. One of the rare rewards of random scanning could be discovering your own comet. But this is no comet. Boosting magnification with a 12mm eyepiece, I can see a definite granular appearance around the edges. This is a globular cluster, about one-third the size of the monster I saw earlier. The core is compact and not quite resolved in a 13-inch. A 9th-magnitude star lies just to the east.

I reinsert the 21mm and am about to move on when my eye catches on a nebulous patch less than half a degree to the southeast. Very faint, smaller, too, than the globular. I reposition and zoom in again with the 12mm, which helps darken the sky background. This thing is tenuous, vanishing completely when I look at it. I tap the tube to see if it jiggles with the vibration. It's definitely there. I screw on an oxygen III filter and pop! it emerges from the background. The O III filter tells all. This is a faint planetary. But which one? I make a mental note to check with an atlas later. Time to replace the 21mm and move on.

Eye in the Sky

I cross a region of glittering stars perforated here and there with regions devoid of light — dark, subtle,

daylight . . . ." — William Herschel (1785)

shapeless nebulae. My telescope points higher now, somewhere just above the celestial equator. The stars here are bright and colorful; the background "noisier" with stars. There's Altair, brilliant blue-white and scintillating in the unsteady seeing this evening. Slew a little east, slew a little west, a little east again . . . .

A small, wisp-of-an-object nearly sneaks unnoticed through the field of view. I look to one side and it brightens a little. Holding the O III filter in front of my eye this tenuous blot takes on some definition. This is also a planetary — round, with a bright, slightly off-center central star within a tight ring. It looks somewhat like an eye. Bracketing the planetary are two faint stars, the brighter of which lies just within the planetary's ring. Strands of stars curl around this delicate object, which is nearly lost in the thick of the Milky Way. If I had been looking for it, I might have never found it.

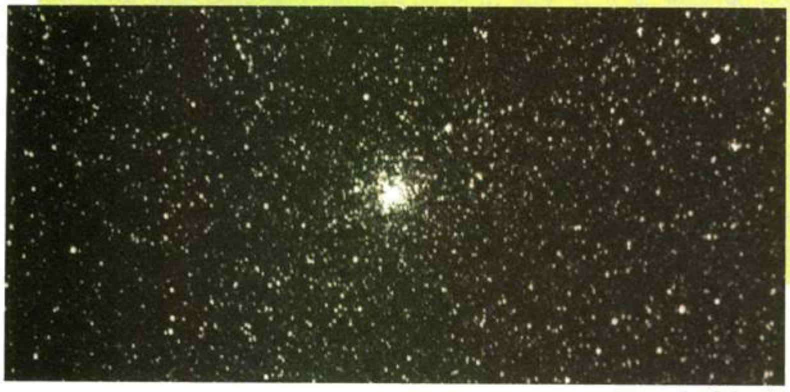
A Mini Pleiades

The telescope wants to move north, so I follow. The stars here are effervescent. I see many pairs and multiples — faint, obscure, beautiful. I nudge the telescope again and at once swing across a distinct stellar grouping comprised of half a dozen 6th-magnitude stars and at least one of magnitude 4. The overall pattern reminds me of a mini version of the Pleiades, not as bright, but nonetheless distinctive. This is a beautiful object in a moderate field of view!

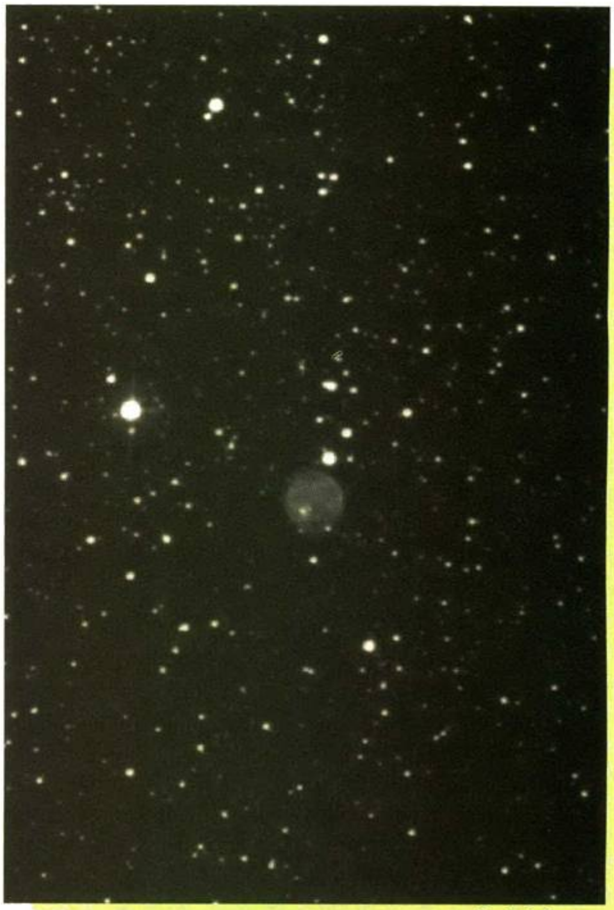
A Loose Globular, and A Star Scattering

Shifting further eastward, the field sweeps up an irregular cloudy patch that, on closer inspection looks either like a tight open cluster or a loose globular. The 12mm eyepiece doesn't do much for it, except resolve two strands of outliers that extend to the northeast, giving that part of the cluster a V shape. An 11th-magnitude star dominates the cluster's center. Similarly bright stars pepper the immediate region. These may possibly be field stars, but they nevertheless add to the subtle beauty of this object.

A loose globular.



Lee C. Coombs



Martin C. Germano

A faint planetary.

Just half a degree to the southwest is a curious scattering dominated by 8th- and 9th-magnitude stars. The brightest ones form a bright pair and a triplet. This is an object many might call a poor catch, especially if you set out to look for it. But coming upon it by happenstance in a little corner of the universe I might have never seen, makes it seem like a treasure.

The Apple Core and the Wraiths

This is an extremely star-rich region, and every field I pass through is replete with mini asterisms, star pairs, and clusters. My east-west sweeps are slow and deliberate; I don't want to miss anything.

A bright nebula suddenly swims into view. What a shock! I instinctively rear back from the eyepiece. This thing is big, hogging the center of the half-degree field of view of my Plössl. It's overall shape is round, but the brighter inner part is bilobed, like an apple core. Boosting power, the object takes on the appearance of a roundish, airbrushed cloud of light. The oval-like center is elongated north to south and a 9th-magnitude star sits at the western edge. Winking in and out

"If I had been looking for it,

Martin C. Germano

A 3-D cluster.

of view near the center is a 14th-magnitude star. The O III filter reveals a "bar" crossing diagonally from northeast to southwest. The two lobes also appear distinctly different: the southern lobe an opaque pall, the northern lobe semitransparent, like a filmy window. Clinical descriptives aside, this is one beautiful object, and I find it difficult to break away.

Ranging northward now, the telescope pointing straight up, I enter the southern realms of Cygnus. Clusters abound along the Swan's neck but I am more intrigued by a drapery of tenuous light lying just east of the constellation. Arched, broad, and long (it stretches out of the field of view of even my 32mm eyepiece), size doesn't translate into definition. This cloud has the appearance of blue smoke wafting against black sky. Sliding the field of view up and down along its length I can see dark filaments, especially along the eastern border. At the southernmost extreme, two appendages extend clawlike from the main trunk. Another cloud, narrower and not as curved lies to the southwest. This nebula appears fibrous; stalky. Near its center is a single bright 4th-magnitude star. Dust extends southward from it in a narrow band like a comet. To the north, however, the dust fans out and disperses entirely. Just east of this narrower cloud lie a few ghostly filaments.

The whole complex reminds me of Webster's definition of a wraith: "A barely visible gaseous or vaporous column." This nebula is more shadow than light; more apparition than substance.

A Faint Planetary and A 3-D Cluster

I replace the 21mm and continue sweeping north, soon coming across a gauzy planetary. It is not quite perfectly round, and lies adjacent to a V-shaped asterism leading southeast. A faint star, slightly off-center, appears to be shining through it. The nebula's western quadrant appears brighter and more defined than those adjacent to it.

The next find is a large, faint, but rich, stellar aggregate. I slip in the 32mm and as blurry stars snap to focus I am astonished to see that the background stars endows this cluster with a depth of field not usually seen in the eyepiece. The center is condensed, with stars running out from it in strings. A number of ruddy stars are among the outliers.

As impressive as this cluster is in size and richness, I am equally awed by a tighter grouping lying in Cassiopeia. What grabs my eye first is a glaring 8th-magnitude star situated alongside a slightly fainter knot of 12th- and 13th-magnitude stars, like a gaudy diamond cast among a group of smaller precious stones. With a 32mm eyepiece, the generous field also takes in a delicate group of stars to the northwest. An interesting contrast in brightness and size. Glancing toward its location in the sky, I see that my telescope is pointing just above the trees.

It's been a fine evening. I found some interesting new objects, saw familiar sites in a new light, and let my instincts lead me where no plan would. There is still plenty of night left, and I am tempted to plow through the Milky Way again. But it's late, and I opt for bed. The beauty of free forming is I can do it again any time, whenever I feel like I don't have to — which is nearly always. ☐

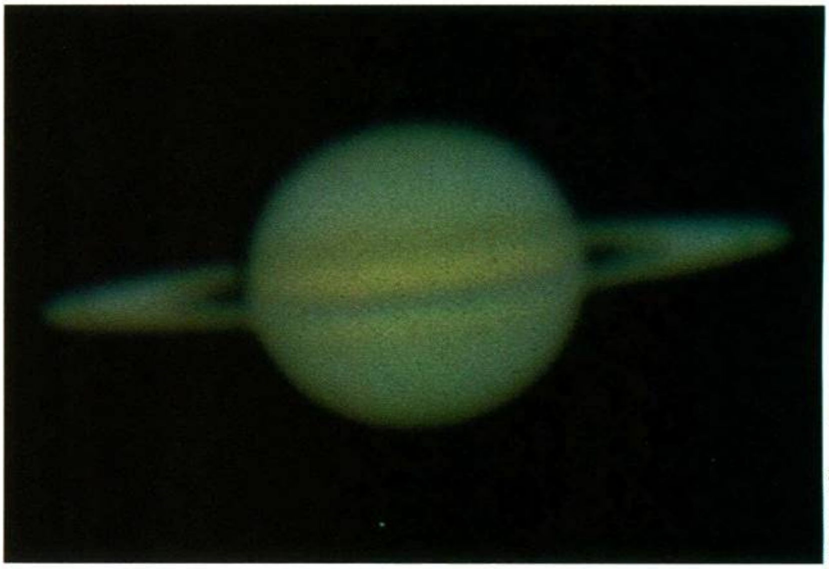
Jeff Kanipe is the managing editor of ASTRONOMY *magazine. If you think you know which objects he saw, send him your list to* ASTRONOMY *21027 Crossroads Circle, Waukesha, WI 53187, or e-mail him at jkanipe@astronomy .com.*

I might have never found it."

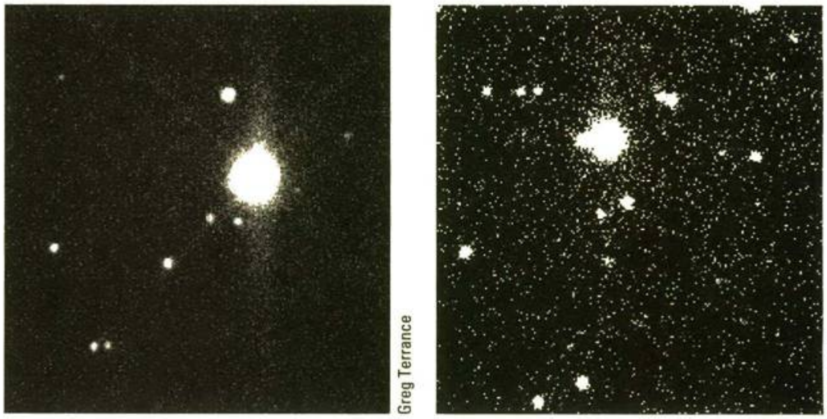
Moonwalking the Outer Planets

This summer's a great time to see Saturn, Uranus, and Neptune and view the never-ending dance of their satellites.

by Richard Talcott


U. S. Naval Observatory

SATURN'S RINGS TILT only about 6° to our line of sight this summer (similar to that seen here), creating less glare than usual and making it easier for backyard observers to spot the planet's moons.


Greg Terrance

Bob Hatfield

YOU CAN EASILY SPOT Neptune (left) and Uranus (right) with binoculars near the border between Capricornus and Sagittarius, but telling their faint moons apart from the background stars is a challenge even for observers with big telescopes.

The warm, quiet nights of late summer set the perfect scene for enjoying a star-studded sky. Whether you want to view the streaks of Perseid meteors, explore the riches of the summer Milky Way, or just lie back and revel in the beauty of a dark sky, nothing beats a tranquil August night.

Each year also brings a few interlopers to add to summer's starry firmament. This year's group includes all four gas giant planets: Jupiter, Saturn, Uranus, and Neptune. By far the most prominent, Jupiter blazes away in northern Sagittarius (see "Jupiter's Magnificent Show," June 1996). But don't let Jupiter dazzle you — the three other gas giants offer their own observing pleasures, from expansive rings to orbiting satellites both bright and faint.

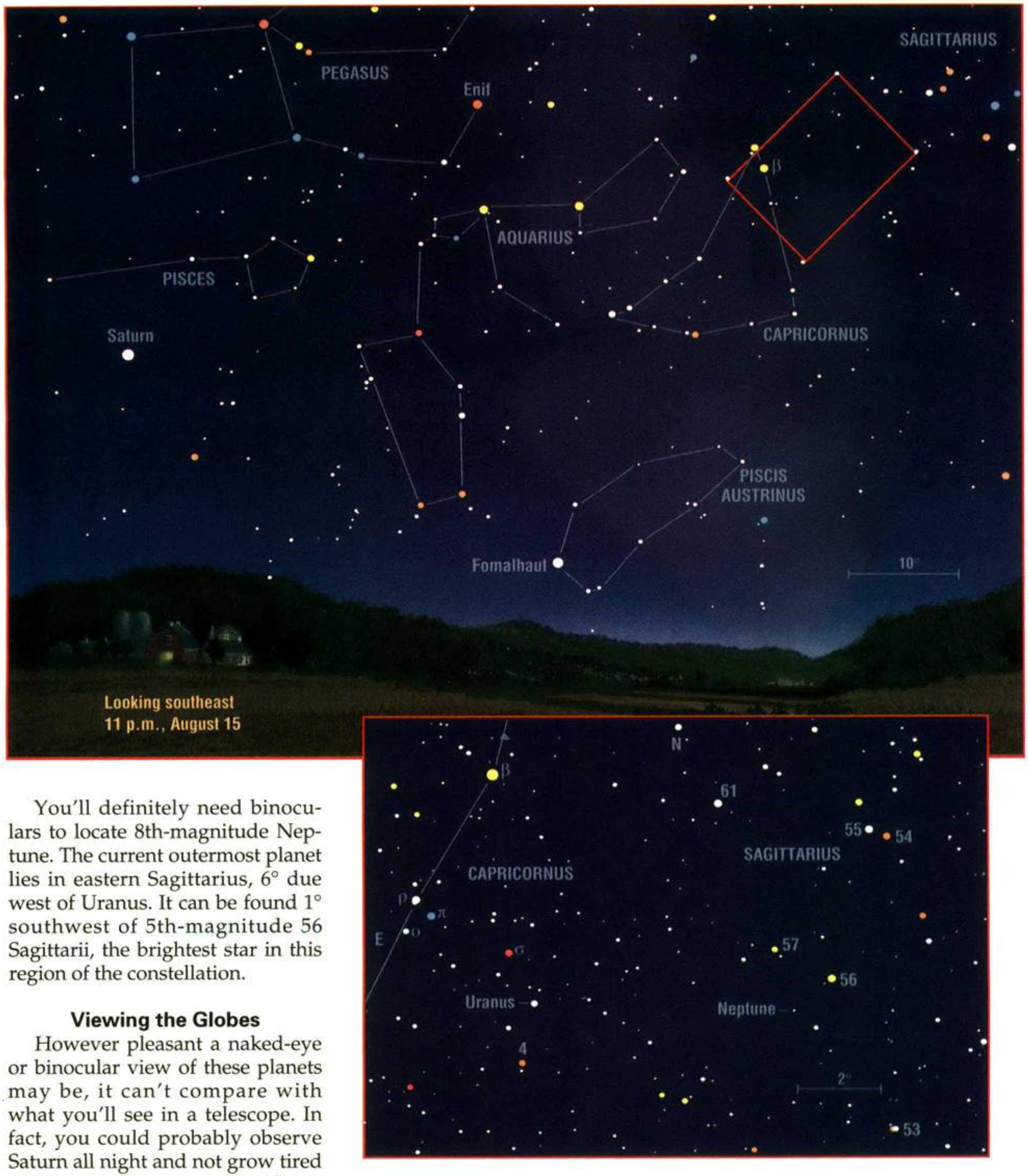
Finding the Outer Three

The most obvious of these three late summer planets rises in the east around 11 p.m. daylight time on August 1 and two hours earlier by month's end. Although Saturn won't reach opposition — when it lies opposite the Sun in the sky and remains visible all night — until late September, by mid-August it appears reasonably high by late evening and continues to gain altitude as dawn approaches.

To find the Ringed Planet, head outside around 11 p.m. and look for the brightest object in the eastern sky. At magnitude 0.6 in mid-August, Saturn easily outshines the faint background stars of Cetus and Pisces, the constellations it traverses this summer.

Locating Uranus and Neptune takes more effort because they appear much fainter than Saturn. Fortunately they also lie higher in the sky, having reached opposition during the second half of July.

First target Uranus, the brighter of the two. It lies in western Capricornus, the constellation just east of Sagittarius and its planetary resident, Jupiter. Your jumping-off point is the 3rd-magnitude star Beta (β) Capricorni, which lies nearly due south in late evening. Uranus lies about 5° south and 1° west of Beta, or halfway between and slightly west of Sigma (σ) and 4 Capricorni (see the map at right). At magnitude 5.7, Uranus appears about as bright as the latter two stars. If you observe from a very dark site, you should be able to glimpse the planet with your naked eye. Binoculars, however, will make the search far easier.


SAGITTARIUS
PEGASUS
Enif
β
AQUARIUS
PISCES
Saturn
CAPRICORNUS
PISCIS AUSTRINUS
Fomalhaut
10°
Looking southeast
11 p.m., August 15
N
β
61
55
54
SAGITTARIUS
CAPRICORNUS
ρ
π
E
ο
σ
57
56
Uranus
Neptune
4
2°
53

All diagrams by ASTRONOMY: Elisabeth Rowan

You'll definitely need binoculars to locate 8th-magnitude Neptune. The current outermost planet lies in eastern Sagittarius, 6° due west of Uranus. It can be found 1° southwest of 5th-magnitude 56 Sagittarii, the brightest star in this region of the constellation.

Viewing the Globes

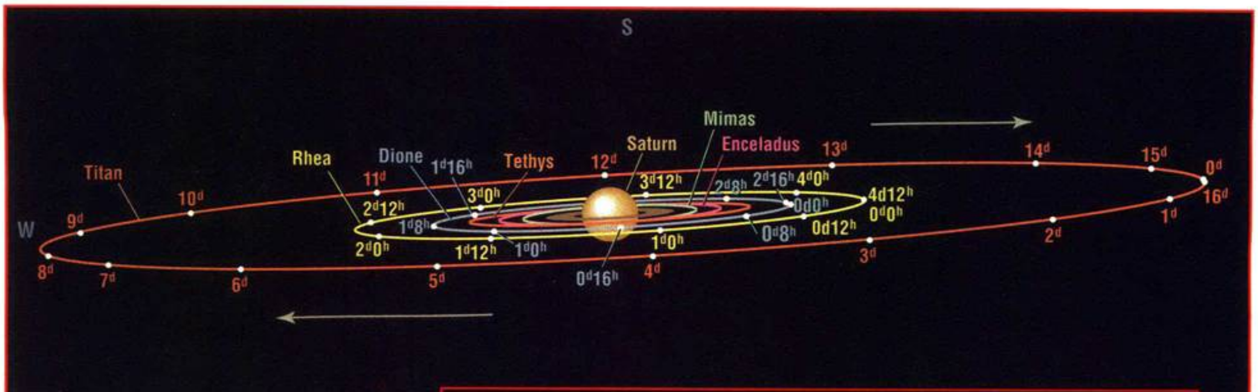
However pleasant a naked-eye or binocular view of these planets may be, it can't compare with what you'll see in a telescope. In fact, you could probably observe Saturn all night and not grow tired of it. Any telescope magnifying 30x or more easily reveals the planet's glorious rings. This month the rings span 43" but tilt just 6° to our line of sight, so they appear flattened. Three times in the last 15 months (most recently in February), the rings have appeared edge-on, and they are only now beginning to open up (see "Saturn's Missing Rings," page 66).

Although the rings naturally draw the eye, don't overlook the planet itself. The first thing you'll notice is the oval shape of the 19"-diameter disk. Saturn's low density and rapid rotation combine to make the planet bulge at its equator, giving it an equatorial diameter 11% bigger than its polar diameter. You also may see a few dusky belts and lighter zones on the ivory-colored disk.

The disks of Uranus and Neptune offer far less to observers with telescopes. That's because both are smaller than Saturn and reside much farther from Earth. All you can hope to see of these two worlds are their colored disks. Uranus shows a 3.7"-diameter disk that appears distinctly blue-green, while Neptune appears 2.3" across and sports a grayish-green color.

Glimpsing Saturn's Moons

Whether you use optical aid or not, you can observe the outer gas giants without a lot of planning. But the same can't be said for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Titan
Rhea
Dione
Tethys
Saturn
Mimas
Enceladus
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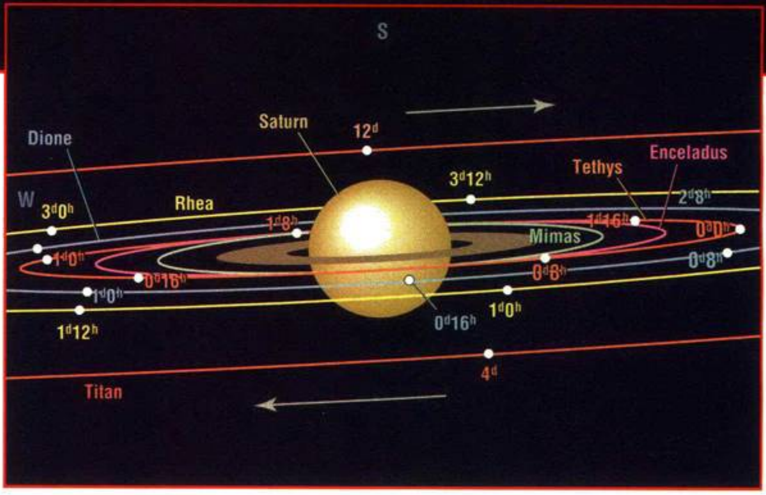
S
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0d0h
1d0h
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0d8h
1d0h
1d12h
0d16h
1d0h
4d
Titan

viewing the satellites of these planets. For all except the brighter moons of Saturn, you need a dark, transparent sky and steady seeing to spot these satellites. Choose your observing site accordingly, and pick a calm night around the time of new Moon in mid-August.

Saturn offers more moons for backyard observers than any other planet. Any telescope reveals 8.3-magnitude Titan, the second largest satellite in the solar system, with a diameter of 5,150 kilometers. It orbits Saturn once every 16 days and appears up to 200" (4.5 ring diameters) from the planet.

Three other moons — Rhea, Dione, and Tethys — lie within reach of a 4-inch telescope. Second in both size and brightness among Saturn's satellites, Rhea measures 1,530 km in diameter and shines at magnitude 9.7. Dione and Tethys have diameters greater than 1,000 km and glow at magnitudes 10.4 and 10.2, respectively. All three orbit closer to Saturn than does Titan, but far enough from the planet to be seen easily.

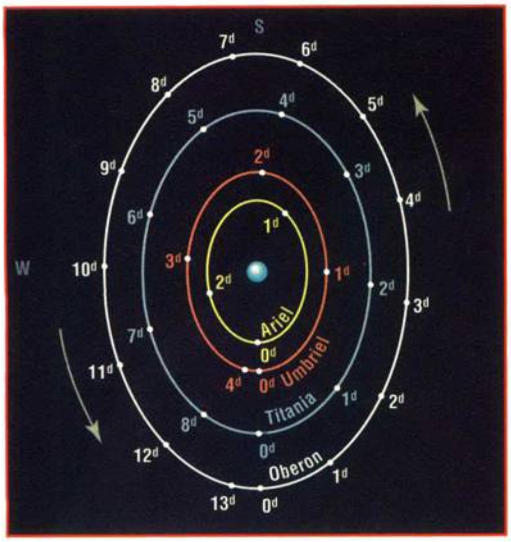
Iapetus ranks as the most intriguing of Saturn's moons. When farthest east of the planet, it glows at magnitude 11.9 and can be hard to see in less than a 6-inch scope. But when farthest west, it appears five times brighter (magnitude 10.1) and is easy to spot in a 4-incher. Why? One of the moon's hemispheres reflects 50% of the sunlight falling on it while the other reflects just 5%. The most distant of Saturn's bright satellites, Iapetus completes one orbit every 79 days and can appear up to 9.5' from the planet.

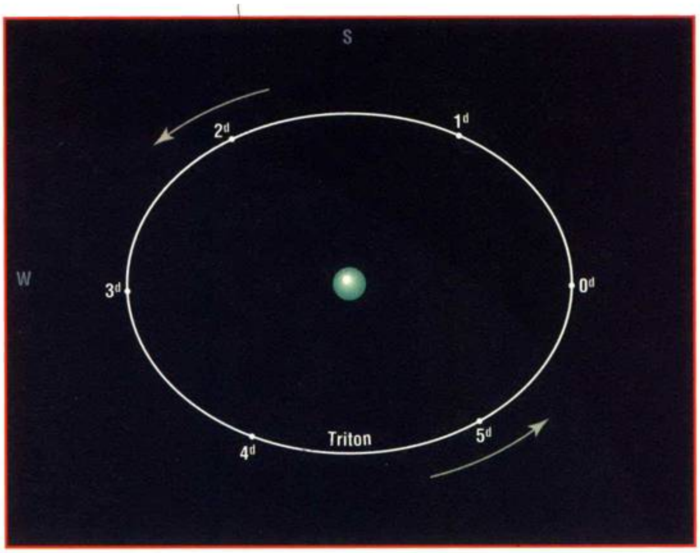
Saturn's Moons

Date	Time (EDT)	Date	Time (EDT)	Date	Time (EDT)
Tethys		**Dione**		**Rhea**	
August 2	6.7 a.m.	August 2	11.7 a.m.	August 1	11.5 a.m.
August 4	4.0 a.m.	August 5	5.4 a.m.	August 5	11.9 p.m.
August 6	1.3 a.m.	August 7	11.1 p.m.	August 10	12.3 p.m.
August 7	10.6 p.m.	August 10	4.7 p.m.	August 15	12.7 a.m.
August 9	7.9 p.m.	August 13	10.4 a.m.	August 19	1.0 p.m.
August 11	5.2 p.m.	August 16	4.1 a.m.	August 24	1.4 a.m.
August 13	2.5 p.m.	August 18	9.7 p.m.	August 28	1.7 p.m.
August 15	11.8 a.m.	August 21	3.4 p.m.		
August 17	9.1 a.m.	August 24	9.0 a.m.	**Titan**	
August 19	6.4 a.m.	August 27	2.7 a.m.	August 3	5.1 p.m.
August 21	3.7 a.m.	August 29	8.3 p.m.	August 19	3.2 p.m.
August 23	1.0 a.m.				
August 24	10.3 p.m.			**Iapetus**	
August 26	7.6 p.m.			August 31	5.4 p.m.
August 28	4.9 p.m.				
August 30	2.2 p.m.				

Two fainter moons round out those visible in a typical backyard scope. Mimas and Enceladus glow at magnitudes 12.9 and 11.7, respectively, but always lie close to the glare from the planet and rings (they lie at most 30" and 38" from Saturn). Because the rings now tilt just 6° to our line of sight, glare is reduced, and the moons are easier to spot than usual. An 8- or 10-inch scope should bring them into view.

The key to finding the moons is knowing when and where to look. The diagrams above show the orbits of the four bright moons and the tables give the times during August when the moons reach greatest eastern elongation. (Times are given in eastern daylight to the nearest 0.1 hour; to convert to





Uranus' Moons

Date	Time (EDT)
Ariel	
August 1	3.8 a.m.
August 3	4.3 p.m.
August 6	4.8 a.m.
August 8	5.3 p.m.
August 11	5.7 a.m.
August 13	6.2 p.m.
August 16	6.7 a.m.
August 18	7.2 p.m.
August 21	7.7 a.m.
August 23	8.2 p.m.
August 26	8.7 a.m.
August 28	9.2 p.m.
August 31	9.7 a.m.
Umbriel	
August 4	11.7 a.m.
August 8	3.2 p.m.
August 12	6.7 p.m.
August 16	10.2 p.m.
August 21	1.5 a.m.
August 25	5.0 a.m.
August 29	8.6 a.m.
Titania	
August 8	9.8 p.m.
August 17	2.8 p.m.
August 26	7.8 a.m.
Oberon	
August 1	12.5 p.m.
August 14	11.7 p.m.
August 28	11.0 a.m.

Neptune's Moons

Date	Time (EDT)
Triton	
August 5	1.8 p.m.
August 11	10.9 a.m.
August 17	8.1 a.m.
August 23	5.2 a.m.
August 29	2.3 a.m.

your local daylight time, subtract 1 hour for CDT, 2 hours for MDT, and 3 hours for PDT.)

On a night you plan to observe, figure where the moons will be by calculating how far each has moved along its orbit since the previous greatest eastern elongation. For example, suppose you observe at 11 p.m. EDT on August 15. Tethys reached greatest elongation at 11.8 a.m. on the 15th, so 11.2 hours have elapsed. From the diagram, you can tell Tethys is out of view (it's passing in front of Saturn). Dione reached greatest elongation at 10.4 a.m. on the 13th, so 2 days and 12.6 hours have elapsed, placing this satellite well east and slightly south of Saturn. Rhea has seen 22.3 hours pass since greatest elongation, and it lies northeast of the planet. And Titan has moved 12 days and 5.9 hours, putting it directly southeast of Saturn.

At the same time, Mimas is just 1 hour from greatest eastern elongation, so it can be found due east of Saturn's disk. And Enceladus is just 2 hours short of greatest western elongation, lying a bit south of due west. The final bright moon, Iapetus, is harder to find because it lies a full 170" (4 ring diameters) east-southeast of the planet.

Going Deep for Moons

While the fainter moons of Saturn are challenging, they're nothing compared with the moons of Uranus and Neptune. But you *can* see them if you follow the same technique for finding Saturn's moons. Simply use the diagrams and tables above to learn where they lie when you plan to observe.

You'll need a 10-inch telescope to spot these moons, but a 12-inch or larger scope makes the task easier. Of Uranus' four observable moons, Titania and Oberon are the easiest to spot. They glow at magnitude 13.7 and 13.9, respectively, and orbit at maximum distances of 33" and 44". Ariel and Umbriel lie closer to Uranus and glow between 14th and 15th magnitude.

Unlike the moons of Saturn, you can see Uranus' moons almost any time because their orbits appear nearly face-on. The tables list the times of greatest northern elongation, but the moons still lie ⅔ of that distance when east or west of Uranus. Neptune's moon Triton, glowing at magnitude 13.5 and lying 17" from the planet at greatest eastern elongation, is about as easy to spot as Uranus' Titania and Oberon.

When you glean these faint points of light, you likely won't be struck by their beauty. But you'll feel a sense of accomplishment that will rival any you've had in backyard observing. ☐

Richard Talcott is an associate editor of this magazine, who plans to spend at least part of this summer viewing the gas giants.

Fish-eye on the Sky

Mark Coco

When it comes to capturing the heavens on film, it pays to go wide.

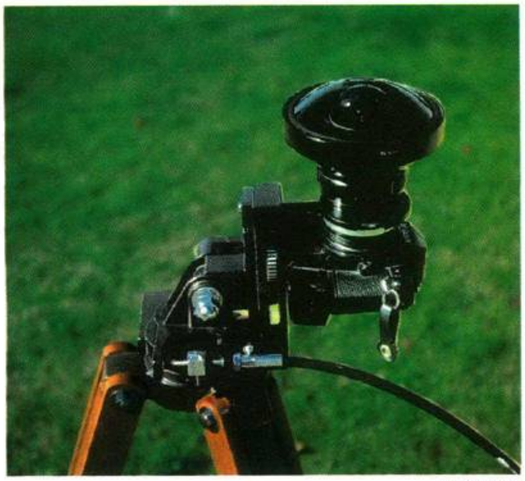
by Mark Coco and
Stephen J. Edberg

There's nothing like looking at the night sky from a pristine site. Stars pepper the celestial dome, the Milky Way meanders overhead, and the zodiacal light may glow in the west shortly after sunset. Too bad you can't capture the whole view on film.

Or can you?

Ultra wide-angle lenses, so-called fish-eye lenses, grab breathtaking 180° views. Although such specialized lenses have very limited terrestrial use, when turned on the night sky they record images that intrigue even the most seasoned celestial photographer.

All-sky photos provide a unique perspective and a different way to learn the heavens. Neophyte stargazers get an idea of where the constellations are and what bright, conspicuous deep-sky objects lie within their borders. Fish-eye photos also convey the night sky's total scale, something narrow-field photographs can't do. You can approach this type of



Mark Coco

FISH-EYE LENSES PULL THE ENTIRE SKY onto one frame of film (opposite page), revealing our home galaxy's edge-on nature. The Milky Way fattens to the south, betraying a hub of stars and gas that surround the Galaxy's center. A tripod-mounted camera fitted with a 8mm lens (near left) took this unguided, 18 minute exposure on ASA 1600 slide film.

astrophotography by either purchasing a commercially made lens or making your own.

Buy Your Own Fish-eye

The quickest way to get into all-sky photography is to buy a commercially made lens. The basic advantage to commercially made lenses is the unobstructed view of the sky they offer. Other wide-angle methods place the camera directly in the middle of the frame.

One problem with commercial fish-eye lenses, though, is expense. An efficient f/2.8 system, like one offered by Nikon, costs over $1,500. "Slower," photographically less-efficient lenses, like an f/5.6 offered by Canon, run about one-third the cost of the Nikon. An alternative to buying a new lens is to rent. Many camera stores, especially those that cater to professional photographers, lease fish-eye lenses for about $25.00 a day.

Still another alternative converts a normal lens to fish-eye by using a threaded "fish-eye" filter. Though they cost an affordable $50, their photographic efficiency and image quality may be disappointing.

One inconvenience a fish-eye lens has that won't go away is its inability to accept thread-in filters. The optical design is such that anything placed in front of the first element vignettes the picture. This does not mean you can't use filters.

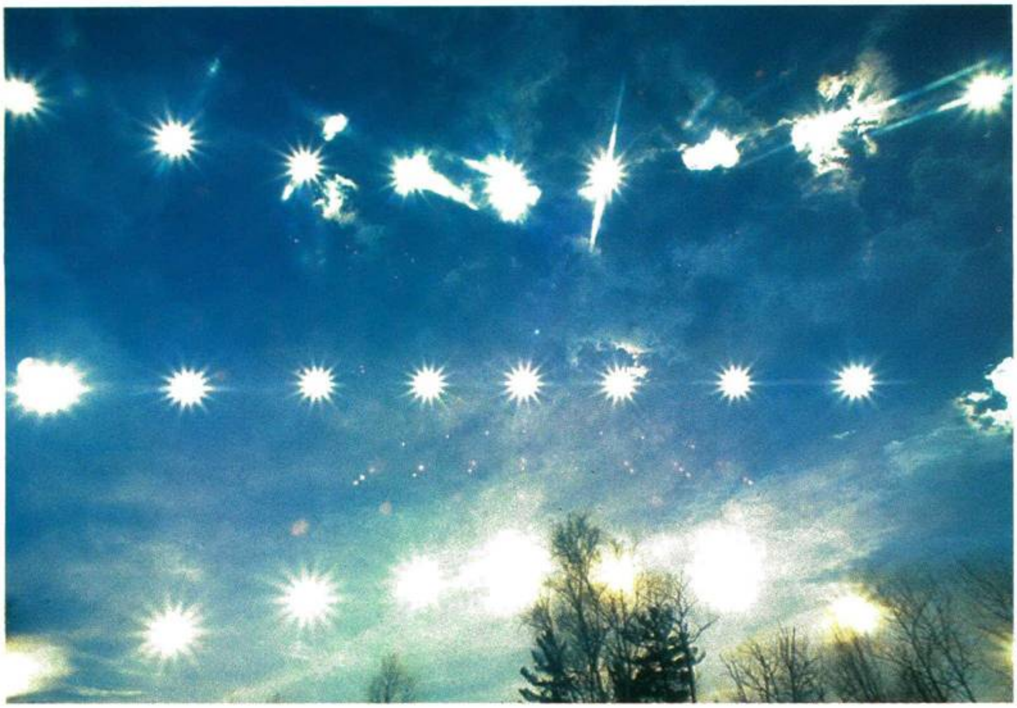
Fish-eye lenses often have built-in filter wheels. The Nikon filter wheel houses a Yellow #48, Yellow #52, Orange #56, Red #60, and an L1 BC. These are only useful for daylight photography, however.

Homemade Fish-Eye Lenses

The least expensive route to all-sky photography is to build the lens yourself. While this may sound difficult, it is actually much easier than you think. Homemade fish-eye lenses use 35mm cameras suspended above round, mirror-like reflectors that yield a 180° field of view, like hub caps, silver Christmas tree ornaments, silvered light bulbs . . . even reflective packaging for women's hosiery.

Image quality will depend upon the quality of your reflector's surface. If it is smooth, like a lens or telescope mirror, it will provide good images. If you see glare or fuzziness in the reflection, so will your camera. Hubcaps, while wonderfully convenient and inexpensive, often have a subtle orange-peel surface.

Next you must figure out how to support the camera above a reflector using one or three legs.



Scott Nielsen

TIME FLOWS from summer into winter on a single, six-month exposure. The summer Sun runs along the top of the frame, while spring transits the center. Winter's Sun treks along the bottom track. Distortion from the fish-eye lens makes each path looked arced. This photographer took 27 shots of the Sun through a solar filter, followed by a foreground exposure.

Targets Only a Fish-eye Could Love

You have an all-sky lens ready to shoot — what should be your target? Here are a few suggestions to get you started.

Night sky — Try a sequence of shots taken every 30 minutes. This shows the progression of stars and Milky Way across the sky and clearly shows how the constellations shift over the course of a night. Do a set for winter, spring, summer, and fall to show how the sky changes from season to season.

Bright comets — An all-sky photo with a bright comet shows how large these objects can get. Next spring's Comet Hale-Bopp promises to be an excellent target; now's the time to practice.

All night — Try an exposure from late evening twilight to early morning twilight that shows the motion of the stars during an entire night. An all night exposure from a high latitude during the dead of winter would show how the stars complete one circle every 24 hours.

All day — This shows the Sun's path across the sky. Such a photo can be made several ways. First, try multiple exposures every 30 to 60 minutes taken on the same frame. Shoot through a Sun-dot solar filter made from 8x10 B&W sheet film (see "Come-As-You-Are Astrophotography," February 1996). During twilight, take an exposure to capture the foreground for context.

A second all day photo would be to let the Sun streak across the frame, like star trails at night. Such a photo must be done with a solar filter to reduce the intensity of the Sun's light, and thus not overexpose the frame. Use a sheet of Mylar solar filter material stretched over the lens. Once again, a normal exposure taken during twilight rounds out the photo.

All night/all day — A 24-hour exposure that shows the motion of the Sun and stars on one frame would be truly interesting. The daytime photo must be filtered so as not to overexpose the solar image. There are several ways to do this type of photo: sunset-to-sunset, sunrise-to-sunrise, or 12 noon to 12 noon. This last option might show the changing motion of the Sun in our sky; the next day's solar disk would not line up exactly with the day before's. The lens should be closed as much as possible while recording the solar image and opened as wide as possible for the star images.

Michel Tournay

SKY-GIRDLING NORTHERN LIGHTS are an easy target for fish-eye lenses. This curtain aurora soared over James Bay, in Canada's subarctic region.

The one-leg method uses a threaded rod to connect the center of a reflector to the camera lens' center. The rod goes straight up from the mirror's center to the camera lens, which is fitted with a clear photographic UV or Skylight filter that accepts the rod.

The filter has a center hole into which the rod attaches with a pair of washers and nuts. You will have to drill this hole into the filter; drill bits that cut glass are available from hardware stores. Sandwich rubber washers on each side of the glass before tightening everything to the rod.

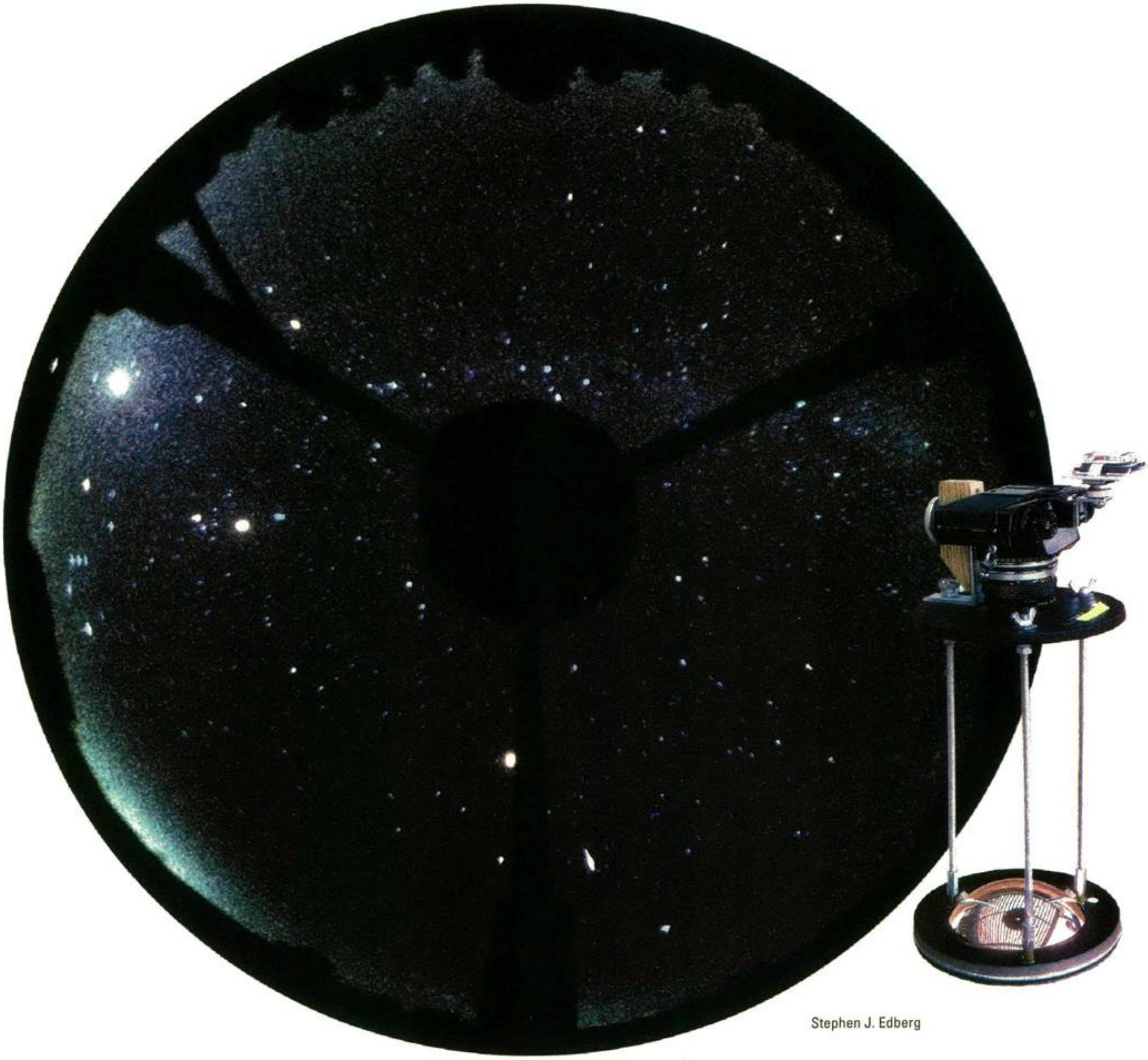
The single-leg approach works well with reflectors strong enough to be drilled through, such as a rigid hubcap. The three-leg approach, on the other hand, works with any type of mirror because the legs straddle the reflector rather than attach to it. The only drawback is that the camera and its three legs show up in the photo silhouetted against the sky. The one-leg technique is appealing because the camera/rod combination is obscured by its own reflection directly over a small area in the reflector.

Regardless of what technique you use, the reflector should fill as much of the camera's field of view as possible. Even then, some of the view, especially the left and right sides, will show the ground. Get around this problem by mounting or laying the reflector on an oversized piece of black fabric. That way the final picture's edges will appear black and featureless.

Remember to put a ¼-20 hole in the reflector's base plate so the assembly can be attached to a telescope mount for tracking the sky or a tripod for star trail shots. Also, be sure the camera is fixed to its mount so it won't fall off at an inopportune moment, especially when you're focusing.

This arrangement might seem hard to focus at first. Use a dry run some evening to focus on the Moon, noting the lens' focus settings for future reference. An extension tube or close-up lens may be necessary to bring the all-sky camera to infinity focus.

Be aware that best focus for one zone of the sky may differ from that of another. Focus the lens on an intermediate zone so that most of the sky is reasonably sharp.



Stephen J. Edberg

REFLECTOR FISH-EYES WORK AS WELL as their more expensive cousins, plus come apart for easy storage or transport. The camera and support struts do show up in a picture as silhouettes, a minor annoyance if one at all.

More of the camera's field of view gets sharper when the lens is stopped down 1 to 2 stops. While this reduces photographic speed, it improves overall image quality.

The Camera Sees

A reality all-sky photographers live with is atmospheric refraction. Starlight that passes through thicker air near the horizon gets dimmer or distorted before it reaches the camera. Thus, all-sky photos show fewer stars near the horizon.

In addition, natural airglow is stronger near the horizon, which may take on the appearance of a very uniform, glowing nebulosity near the picture's edge.

Another effect that shows up in fish-eye photography is field rotation. This occurs when the camera's equatorial mount is poorly polar aligned. The result is an image that shifts around one fixed point on the frame.

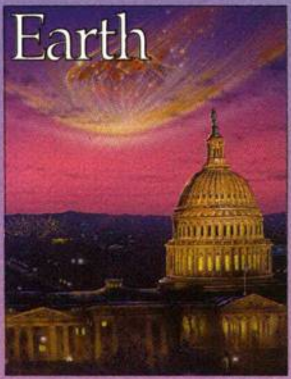
You can avoid this problem by carefully aligning an equatorial mount upon which the fish-eye arrangement piggy-backs.

These concerns pale, however, when you consider everything fish-eye photography offers. The Milky Way suddenly takes on an entirely new character. Constellations appear as compact as those on a planisphere.

Finally, an image of the entire sky conveys a sense of grandeur that smaller scale photos do not. That could explain why all-sky photography is popular with hundreds of astrophotographers and may appeal to you, too. ☐

At press time we were saddened to hear of the death on May 21, 1996, of longtime contributor and skilled astrophotographer Mark Coco. Mark's many years of astronomical experience will be sorely missed by the amateur astronomy community. An article describing Mark's many achievements will appear in the September ASTRONOMY.

In the AUGUST issue



The Threat From Space

Asteroids and comets have repeatedly slammed into our planet, at least once killing much of life on Earth. Scientists are working to resolve when the next catastrophic impact might occur and to determine what we can do about it.

The Great Museum Makeover

The dust is flying in history of life exhibits across the land. But when it settles, will the revamped displays better serve the public?

Earth

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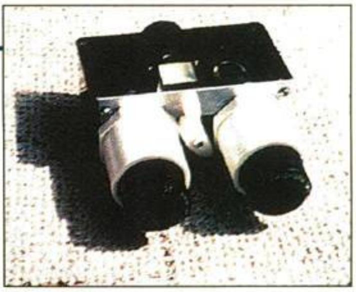
NEW PRODUCTS



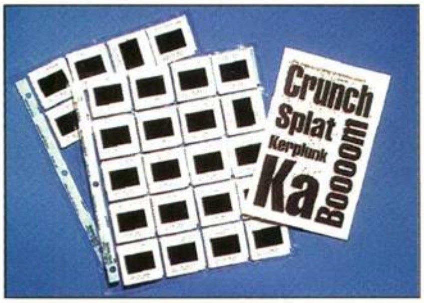
Binocular Viewer Kit

TL Systems offers a low-cost kit to build your own binocular viewer for use with 1.25-inch focusers. The viewer works with virtually any telescope if it's used with a Barlow lens to compensate for the increased light path. Eyepiece separation adjusts from approximately 55 mm to 70 mm. The kit is complete except for the optics, which are readily available from optics suppliers.

TL Systems, 2184 Primrose Ave., Vista, CA 92083; (619) 599-4219; e-mail, tlsystem@ix.netcom.com; Web site, http://www.nbn.com/people/sunspot/tlsystems. Binocular Viewer Kit: $109.

Comet Crash Slide Set

The Astronomical Society of the Pacific offers this set of 25 slides containing some of the best images from Comet Shoemaker-Levy 9's impact with Jupiter. The set includes the original discovery images, early images of the comet, schematics of the comet's orbit, impact sequences in visible and infrared light, views of impact-related aurorae on Jupiter, and images of the impact sites as they changed over the months following the collision. Observatories that contributed to the set include the Hubble Space Telescope, the Very Large Array, the European Southern Observatory, the Australian National Observatory, the South Pole Infrared Explorer, and the Galileo spacecraft. Elizabeth Roettger of the Adler Planetarium selected each of the set's images and compiled its 18-page explanatory supplement.

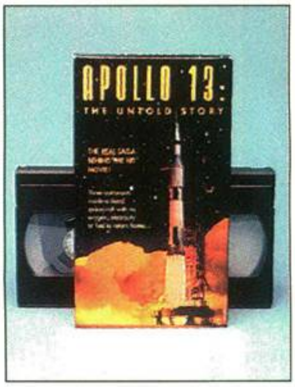


Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco, CA 94112; (415) 337-2624 or (800) 335-2624; fax, (415) 337-5205; e-mail, asp@stars.sfsu.edu. Jupiter Impact Slide Set: $29.95, plus $5 shipping and handling; $8 overseas S & H; California residents, please include sales tax

Apollo 13 Video

The producers of *Apollo 13: The Untold Story* have accessed over one million feet of film from NASA archives, some of which has never been seen by the public. Their documentary film looks at the Apollo 13 mishap through the recollections of mission control staff, flight directors, simulation instructors and back-up crews. Billy Mumy of Lost In Space fame hosts the 50-minute program.

Kultur/White Star, 195 Highway 36, West Long Branch, NJ 07764; (908) 229-2343; fax, (908) 229-0066. Apollo 13: The Untold Story, Item # 1727: $19.95. Available in VHS format only.



New Products presents announcements issued by manufacturers. ASTRONOMY assumes no responsibility for the product information supplied. Prices are suggested retail. Suppliers should send announcements and color photographs to the attention of John Shibley, P.O. Box 1612, Waukesha, WI 53187, or newprod@astronomy.com.

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Astronomy for the Beginner	P. Moore, 7x9", 48 pgs.	13
Bright Star Atlas	Wil Tirion, 9x12", 36 pgs.	11
Chasing the Shadow	J. Harris, 7x9", 160 pgs.	19
City Astronomy	R. Scagell, 6x9", 176 pgs.	19
Dictionary of Astronomy	J. Mitton, 5x8", 430 pgs.	13
Discover the Stars	Richard Berry, 7x9", 119 pgs.	13
Messier Album	J. Mallas, 6x9", 248 pgs.	20
Monthly Star Charts	Sky&Tel Mag., 11x14", 68 pgs.	25
New Cosmos	Astronomy Mag., 8x11", 160 pgs.	20
Observers Sky Atlas	E. Karkoschka, 5x7", 131 pgs.	15
Observing Variable Stars	David Levy, 7x10", 198 pgs.	25
Phillips Color Star Atlas	J. Cox, 11x15", 40 pgs.	20
Sky Catalog 2000.0 vol.1	A. Hirshfeld, 9x12", 704 pgs.	40
Sky Atlas 2000.0 Deluxe	Wil Tirion, 11x16", 385 pgs.	45
Star Hopping	A. MacRobert, 9x11", 160 pgs.	22
Turn Left at Orion	G. Consolmagno, 8x11", 205 pgs.	28
The Moon	Astronomy Mag., 8x11", 80 pgs.	12
Urban Astronomer	7x10", 224 pgs.	15
Uranometria 2000.0 vol.1	Wil Tirion, 10x12", 260 pgs.	40

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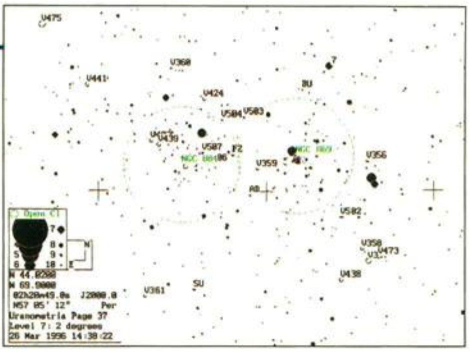
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N 44.0200
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N57 05' 12" Per
Uranometria Page 37
Level 7: 2 degrees
26 Mar 1996 14:38:22

Guide 4.0

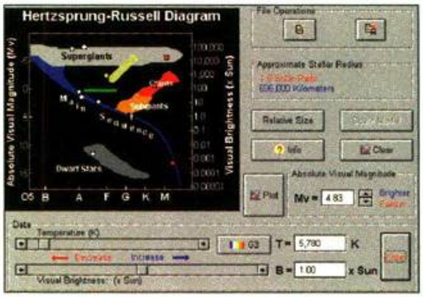
Guide handles both planetarium and detailed star chart tasks, displaying views of the entire sky down to fields a few arcminutes across. It uses the *Hubble Guide Star Catalog, Position and Proper Motion* catalog, *New General Catalogue, Principal Galaxy Catalog,* and many others. Users can select individual types of objects to display and set their limiting magnitudes; for example, all variables brighter than 14th magnitude, but galaxies to magnitude 8. *Guide* also displays the Sun and Moon, planets, 700 comets, and 10,000 asteroids. A red screen mode saves night vision, and the program can control LX-200 and Sky Commander telescope systems.

Project Pluto, Ridge Road, Box 1067, Bowdoinham, ME 04008, (207) 666-5750, fax (207) 666-3149, e-mail pluto@genie.geis.com. Price: $49.95. Minimum requirements: 80286-based computer, CD-ROM drive, and EGA display. An 80386-based computer, mouse, and VGA graphics recommended.

H-R Calc 2.0

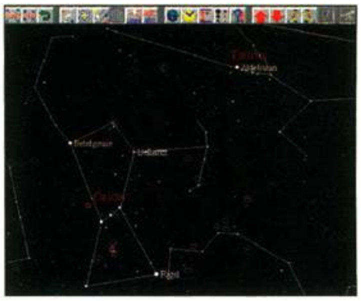
Enter a star's luminosity and temperature to determine its radius and plot its disk against that of the Sun. Giant and supergiant stars use the solar system for comparison. *H-R Calc* plots the star's position in the temperature-luminosity plot, which is also known as the Hertzsprung-Russell diagram. It includes a list of selected stars.

David Irizarry, check out the shareware library at http://www.shareware. com. Price: $15. Minimum requirements: IBM PC-compatible computer and Windows 3.1 or Windows 95.


Hertzsprung-Russell Diagram
Absolute Visual Magnitude (Mv)
Visual Brightness (x Sun)
Supergiants
Giants
Subgiants
Main Sequence
Dwarf Stars
O5 B A F G K M
100,000
10,000
1,000
100
10
1.0
0.1
0.01
0.001
0.0001
0.00001
File Operations
Approximate Stellar Radius
Relative Size
Info
Clear
Plot
Brighter
Fainter
Data
Temperature (K)
Decrease
Increase
Visual Brightness: (x Sun)
G2
K
x Sun

Approximate Stellar Radius: 696,000 Kilometers
Absolute Visual Magnitude: Mv = 4.83
T = 5,780 K
B = 1.00 x Sun

Product information is provided by the developer. Software developers may send new programs and upgrades to AstroBytes, ASTRONOMY *Magazine, P.O. Box 1612, Waukesha, WI 53187-1612 or e-mail bytes@astronomy.com. Check out* ASTRONOMY*'s home page at* http://www.kalmbach.com/astro/astronomy.html



Earth Centered Universe 2.0B

This version of *Earth Centered Universe,* a planetarium and telescope-control program, incorporates a local horizon mode, ability to access the *Hubble Guide Star Catalog,* and version 6.0 of the Saguaro Astronomy Club database of deep-sky objects. Additionally, it includes correct depiction of the Moon's terminator, function toolbar, improved database search capability, extended label support for objects, and angular separation measurement for Dobsonian telescope owners who use offsets.

Nova Astronomics, 4-26 Randall Ave., P.O. Box 31013, Halifax, Nova Scotia B3K 5T9, Canada, (902) 443-5989, fax (902) 445-5790, e-mail dlane@hercules.stmarys.ca, http://fox.nstn.ca/~ecu/ecu.html. Price: $50. Minimum requirements: 80386SX-based computer, 3.4 MB of free hard disk space, 1 MB of memory free within Windows, EGA graphics, mouse, DOS 3.X and Windows 3.1. Super VGA graphics and 80486-based computer are recommended.

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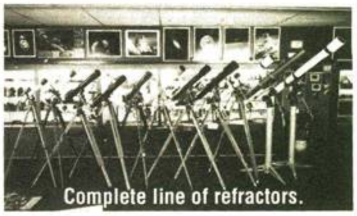
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NEW! Bino Vue binocular viewer	**$899**
Gibraltar mount with ash wood tripod	**$495**
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8, 11, 15mm Plossl **$89**, 20, 25mm	**$99**
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7mm Nagler, 1¼" eyepiece, 82° field	**$219**
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15mm Panoptic 1¼", 68° field	**$209**
22mm Panoptic 1¼"/2", 68°	**$269**
27mm Panoptic 2", 68° field	**$319**
35mm Panoptic 2", 68° field	**$349**

NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 2.1" enhanced aluminum diagonal mirrors & 1¼" star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. The extra 5-10% transmission is like adding up to an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32"	**$39.50**	1.52"	**$45.00**	1.83"	**$49.50**
2.14"	**$59.50**	2.60"	**$75.00**	3.10"	**$99.50**

ENHANCED ALUMINUM STAR DIAGONAL

90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror)	**$99.50**
2" (1.83" mirror)(see photo above)	**$189.50**

LUMICON FILTERS — BEST IN THE WORLD!

"The LUMICON O-III proved to be our favorite... It gave the greatest contrast gain." ***ASTRONOMY*, February 1991**

AMAZING O-III FILTER™

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

GREATLY ENHANCED DETAIL

"Consistently performed well on all emssion and planetary nebulae. Detail and structure were greatly enhanced in the more than two dozen objects I viewed." ***SKY & TELESCOPE*, July 1995**

BETTER THAN A DARK-SKY SITE!?

"From my light polluted backyard, the view ... was better with the O-III than with any other filter tested. The view was even better than without the filter from a dark-sky site." ***SKY & TELESCOPE*, July 1995**

SEE THE HORSEHEAD!

*"**LUMICON's H-Beta Filter** will show subtle features in emission nebulae that the others fail to reveal. It can't be beat for the elusive Horsehead and California nebulae. . ."* ***SKY & TELESCOPE*, July 1995**

"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*

Rich Zepernick, Cresskill, NJ

DEEP-SKY FILTER™

BEST for Astrophotography!

"Stunning is all I can say," says noted astrophotographer Jack Newton. Great for BOTH color and black and white photography.

BEST WIDE-BAND FILTER!

*"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for **reflection** nebulae."* ***ASTRONOMY*, February 1991**

	Premium*
0.96" LUMICON DEEP-SKY Filter threads into most 0.96" eyepieces	$59.50
1¼" LUMICON DEEP-SKY Filter threads into most 1¼" eyepieces	$79.50
48mm LUMICON DEEP-SKY Filter (1.7" aperture), threads into most 2" eyepieces. Also fits LUMICON EASY-GUIDERS	$119.50
2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography	$119.50
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $10, 82mm $16)	$299.50
2" Rear Cell Filter, fits SCT's Deep-Sky, **$119.50** UHC, O-III, H-Beta,	$199.50
1¼" LUMICON UHC Filter threads into most 1¼" eyepieces	$99.50
48mm LUMICON UHC Filter (1.75" aperture) fits most 2" eyepieces	$199.50
DEEP-SKY and choice of **UHC, O-III or H-BETA** Filter (**Save 11%**) 1¼" **$159.50**; 48mm	$279.50
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼"** **$99.50, 48mm**	$199.50
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines **1¼" $99.50; 48mm**	$199.50
LUMICON Comet (Swan band) Filter **1¼" $99.50; 48mm**	$199.50
Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm	$7.95
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece	$19.50
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece	$25.00

**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.

LUMICON Adjust. Piggyback Mount $59.50
Specify telescope size: 6", 8", 10", 11", 14", 16"

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the LUMICON Deep-Sky (DS) Filter.

Specify Lens Size	H-Alpha	(DS)
46, 48, 49mm	$59.00	$119.50
52, 55, 58, 62mm	$69.00	$119.50
67, 72, 77mm	$79.00	$299.50
82mm (77mm + adapter)	$89.00	$315.00

Hypered 2415 film, 36 exp .. **$11.95, $3/$32**

LUMICON®
2111 Research Dr. #5A, Livermore, CA 94550
For phone orders please call (510) 447-9570
FAX (6 PM-9 AM PST) (510) 447-9589
LUMICON Products catalogue FREE
All foreign orders add 8% ($10 minimum)
California residents add 8.25% tax.
Prices subject to change w/o notice.
Hrs: M-F 9 am - 5 pm, Sat. 9 am - 1 pm

DEEP-SKY ASTROPHOTOGRAPHY

SR-V 3200 NEW FILM

FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

†U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$325**

MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$395**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller ... **$595**

Temperature controller for any HYPER-KIT **$75**

Electric Vacuum Pump, Model R-10 **$325**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars. †U.S. Patent 4,448,500
Specify Camera and Telescope type.

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in seconds. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER	**$189.50**
48mm Coma corrector/field flattener	**$285**
3X Relay Diagonal (see photo)	**$99.50**
Illuminated reticle eyepiece, pulsed	**$109.50**
Guider for Hasselblad **$409,** Mamiya 645	**$199**
Pentax 6X7 **add $119;** Pentax 645	**add $139**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER	**$249.00**
Adapter for Hasselblad **$225,** Mamiya 645	**$98**
Pentax 6X7 **add $119;** Pentax 645	**add $139**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10-12" Meade. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER	**$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20)	**add $99.95**
Adapter for Hasselblad **$295,** Mamiya 645	**$149**
Pentax 6X7 **add $129;** Pentax 645	**add $149**

WHAT DO YOU NEED?

1. **Illuminated reticle eyepiece** ... **$109.50** Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, pulsed.
2. **Cable release** for long exposures **$9.95**
3. **Declination motor** (state telescope type) **$109**
4. **Dual-axis drive corrector** for telescope. This should be part of the telescope when purchased. Call LUMICON for details.
5. **LUMICON EASY-GUIDER** (selection to left)
6. **LUMICON 48mm DEEP-SKY FILTER $119.50** This is essential for highest possible contrast. Contrast is boosted up to 3X for ***both*** color or black & white photos. The 3 photos in this ad showing the Helix Nebula, Horsehead Nebula and Veil Nebula were all made using a LUMICON 48mm DEEP-SKY FILTER.
7. **Hypersensitized film.** Purchase from LUMICON or make your own with a LUMICON HYPER-KIT.

HYPERSENSITIZED FILM

SR1600
Scotch
1000
TP 135-36

HYPERED FILM IS 2-10X FASTER!

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.). ***No C.O.D.s.***

Film Type, 35mm	Exposures	Price
2415, Ultra-fine B&W, red sens.	36	**$11.95**
SR-G3200, fastest of all, color neg	24	**$14.95**
Kodak Gold 1000 fast, fine grain	12	**$13.95**
Fuji G800 fine grain color neg.	**24**	**$13.95**
Ektachrome 1600, fast slide film	24	**$14.95**
Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$6.95**

LUMICON® ACCESSORIES | MEADE® TELESCOPES

TOLL-FREE ORDER LINE 1-800-767-9576 EXPERT INFORMATION 1-510-447-9570 FAX 1-510-447-9589
LUMICON, 2111 Research Drive, Suites 4-5, Livermore, CA 94550 OPEN M-F 9-5, SAT 9-1 PST

LED FLASHLIGHT . $14.95

LUMICON LUMILITE™ Red LED Flashlight

This red LED flashlight preserves night vision. It uses 2 AA cells (included!) which last 60-100 hours.

LUMILITE red LED flashlight	**$14.95**

DRIVE CORRECTORS

LUMICON UNITRAK DRIVE CORRECTOR

Operate your telescopes ***anywhere!*** Use the single-axis Unitrak with a 12V DC car battery. The dual-axis drives are for photography and use either 12V DC or 125V AC.

Unitrak™ single-axis corrector	**$99.95**
Unitrak with hand controller	**$139**
Convenient rechargeable Porta-Pac battery: 12V DC Porta-Pac (5AH) & recharger	**$89.50**

48MM COLORED FILTERS

FOR EVERY NEED

Select 48mm UV, Red, Yellow, Green (ea.)	**$24.00**
48mm Cyan (absorbs red)	**$69.00**
48mm High Performance Blue (95% T)	**$59.00**
48mm Tri-Color Blue (80% T- 400nm) .	**$59.00**
48mm Ultraviolet (85% T- 370nm)	**$59.00**
Color Separation Set: cyan, red, yellow, blue	**$159**

RICH FIELD! 2° in 8'' SCT

NOW ONLY

$99.50

LUMICON Rich-Field Viewer on C-8 with LUMICON 2'' star diagonal and 2'' eyepiece.

The LUMICON Rich-Field Viewer fits **all** commercial Schmidt-Cassegrain telescopes. It has a high-performance coated achromatic focal reducing lens with 50mm or 80mm clear aperture for **totally unvignetted viewing** with 2'' or 1¼'' eyepieces. It is available in several combinations depending on the eyepiece and field-of-view you desire (see chart below).

LUMICON Rich-Field Viewer	**$99.50**
Giant Rich-Field Viewer (10-14'') ..	**$250.00**

Optional Eyepiece	**TRUE FIELD**	**Price**
Meade 32mm Plossl	1.4°	**add $99**
Meade 32mm 2'' Wide-Field†	1.9°	**add $459**
Meade 40mm 2'' Wide-Field†	2.4°	**add $519**

†Includes 2'' enhanced aluminum Star Diagonal (may not reach focus on some telescopes).

PROTECTIVE DUST COVERS

Protect your valuable telescope optics, eyepieces and accessories with these black vinyl covers. Add $1 shipping. Deduct 10%, 2 or more sets.

1¼'' O.D. plug, seals focuser	**4/$2**		
2'' O.D. plug	**2/$2**	3½'' O.D. plug	**$1.50**
1¼'', 1⅜'' ...	**3/$2**	7½''	**$10**
1½''	**2/$2**	9½'', 10.4''*	**$15**
2''	**2/$2**	12½'', 12⅞''* ...	**$20**
2⅛''	**2/$20**	15.0'', 15.6'', 16''*	**$28**
5½''	**$6**	19'' (DS-16)	**$35**
*Fits Odyssey		21'' (Odyssey-II)	**$35**

MEADE 7'' - 16'' LX200
NEW! 7'' - 10'' LX50

16'' LX200 $14,950

Meade 8'' LX200 Telescopes

LX50 - includes dec. motor, hand controller.
LX200 - full computer control w/64K obj. mem.
Tripod: extra for LX50; included for LX200
NOTE: A wedge is **not** needed for visual observing with the LX200 Drive. Select f/10 or f/6.3 (no extra charge) for your LX200.

NEW! 3.5'' f/14 ETX Maksutov ($20)	**$495**
NEW! 8'' LX50 w/wedge ($105 P&S) ..	**$1395**
Tripod for 8'', 10'' LX50 ($30 P&S)	**$295**
8'' LX200 w/computer ($105 P&S)	**$2795**
Wedge for photographing w/8'' LX200 ..	**$139**
7'' LX50 f/15 Maksutov w/wedge ($125 P&S)	**$1795**
10'' LX50, f/10 w/wedge, dec. motor, hand controller ($145 P&S)	**$1695**
10'' LX200 w/computer ($145 P&S)	**$3195**
12'' LX200 (f/10 only)($215 P&S)	**$4495**
Super Wedge for photogr. w/10'',12'' LX200	**$395**
16'' LX200 f/10 w/tripod ($385 P&S) .	**$14,950**
Dew Shields: 8'' .... **$119;** 10''	**$129**
12'' .... **$189;** 16''	**$289**

OTHER SCHMIDT-CASSEGRAINS

Meade 2045D 4'' f/10 w/motor ($40 P&S)	**$699**
Model 2120B 10'' w/wedge, tripod ($75)	**$1699**

PHOTOGRAPHY ACCESSORIES

Cassegrain EASY-GUIDER 4'', 8'', f/6 or f/10	**$249**
Giant EASY-GUIDER for 10''/12'' f/4-f/10 .	**$395**

MEADE STARFINDERS

New 8'' f/6 Meade Starfinder telescopes

See the Meade ad in this magazine for full descriptions. These are complete telescope systems with motor drive & finderscope (equat. only), mount, and 25mm (=48X) eyepiece. New DC motor runs on 4AA batteries.

6'' f/8 Dobsonian Starfinder ($46 P&S)	**$349**
6'' f/8 Equat. Starfinder 6(add $79 P&S) ...	**$649**
8'' f/6 Dobsonian Starfinder (add $59 P&S)	**$469**
8'' f/6 Equat. Starfinder 8 (add $89 P&S) ...	**$749**
10'' f/4.5 Dobsonian Starfinder ($85 P&S) ..	**$649**
10'' f/4.5 Equat. Starfinder 10 (add $99 P&S)	**$879**
12.5'' f/4.8 Dobsonian Starfinder ($95 P&S)	**$895**
16'' f/4.5 Dobsonian Starfinder (freight COD)	**$1195**
16'' f/4.5 Starfinder 16 (ship. freight COD) .	**$2695**

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated packing & shipping charge to the price. Slightly lower P&S for payment by check. LUMICON showroom prices are $50-$100 higher.

ACCESSORIES

LUMICON carries all Meade accessories.

LUMICON Single axis drive corrector .	**$99**
Magellan computer; specify Dob. or Eq. ($15 ship)	**$295**
Meade 47M Dual-axis drive corrector with tangent arm & electric declination ..	**$475**

SKY VECTOR™ $299!!

Includes Computer, Encoders, Hardware

LOW PRICE—from $299

LUMICON SKY VECTOR FEATURES:

- "GUIDE" mode leads you to object
- Digital right ascension readout to 1 min.
- Digital decl. readout to 10 arc-min.
- 4000 pulse (0.09° accuracy) encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, etc.

SKY VECTOR I™ $299

NEW! With over 220 object memory including the 110 Messier and 58 best NGC objects.

SKY VECTOR II™ $349

IMPROVED — Planets, Over 3,700 Objects! With size, magnitude and full visual description.

NGC SKY VECTOR™ $439

IMPROVED!—5500 Additions / Corrections

NGC-Sky Vector
OFF ON
DIM
MODE
ENTER
UP
DOWN
LUMICON

NGC SKY VECTOR with IDENTIFY (Sky Tour) mode, 12,000 object memory including the corrected RNGC catalogue, IC catalogue, P&K planetary catalogue, & much more!

Specify Telescope Type: Meade 2045, 2080, 2120, C-8, C-11, Odyssey 8, 10, 13, 17½, Alt-Azimuth, Meade 6-16'' Dobsonian.

Ultima 8, 9¼, 11 **add $25**, C-14 **add $75**

COMA CORRECTOR

Coma 1 inch off-axis 17½'' f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2'' lens reduces coma and flattens the field for both viewing and photography. **It threads into LUMICON 2'' EASY-GUIDERS for effortless installation.** This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Clear aperture = 1.8''.

LUMICON 48mm Coma Corrector/Field Flattener Lens	**$285.00**
LUMICON 2'' EASY-GUIDER .	**$189.50**
2'' EASY-GUIDER (Mamiya 645)	**$239.50**
2'' Adapter for Pentax 6X7 ...	**$129.00**
2'' Adapter for Hasselblad .	**$229.00**
2'' Adapter for Bronica SQ-A	**$175.00**
2'' Extension for viewing ...	**$26.00**

2'' DELUXE BARLOW

1.8x Multiplier Lens (2'' Barlow)

LUMICON 1.8x Multiplier Lens (2'' Barlow)	**$259.00**

LUMICON ACCESSORIES

LUMICON, Livermore, CA 94550 (510) 447-9570 FAX (510) 447-9589

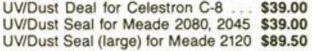
LARGE UV/DUST SEAL

Protect the optics of your 8-14'' Schmidt-Cassegrain with a UV/Dust Seal. Simply thread it onto the rear cell, then attach all normal accessories. The large size fits Meade 2120, Celestron-11 and -14 & has a high quality multi coated (removable) 72mm UV filter.

Deep-Sky Filter/Dust Seal for C-8, 2080 ...	**$119.50**
UV/Dust Deal for Celestron C-8 ...	**$39.00**
UV/Dust Seal for Meade 2080, 2045	**$39.00**
UV/Dust Seal (large) for Meade 2120	**$89.50**
UV/Dust Seal for Celestron-11, -14 .	**$89.50**

LOW PROFILE FOCUSERS
New! Thread-on for Odyssey

FROM $69.50



LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½'' above the telescope tube. Use the 1¼'' or 2'' versions for viewing. Use the 2'' non-rotating focuser for convenient photography with the LUMICON 2'' EASY-GUIDER™.

Select your desired base-plate shape! Coulter Odyssey (thread-on installation), Flat, 7'' OD, 9½'' OD, 12½'' OD, 16'' OD, 21'' OD.

LUMICON 1¼'' Helical Focuser	**$69.50**
LUMICON 2'' Helical Focuser 1½'' high	**$75.00**
LUMICON Non-rotating Helical Focuser	**$129.00**
2'' Astro Systems focuser, only 2'' high	**$139.00**
3 handles for non-rotating focuser	**$12.95**
2''/1¼'' adapter w/48mm filter threads	**$20.00**
2'' LUMICON EASY-GUIDER	**$189.50**

LUMICON 50mm, 80mm SUPER-FINDER™

Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

1¼'' 50mm Finderscope **$69.50**, 45°version	**$69.50**
1¼'' straight-thru 80mm SUPER-FINDER .	**$189.50**
1¼'' right-angle 80mm SUPER-FINDER ..	**$199.50**
1¼'' right-angle version, w/star diagonal ..	**$239.50**
25mm Cross-hair 1¼'' eyepiece (12X)	**$59.00**
Large mounting rings for 80mm Finder	**$55.00**
1¼'' Star Diagonal **$49**, Mounting Brackets,	**$39.50**
1¼'' 45° diagonal for correct left-right views	**$59.50**

LOTS OF ADAPTERS

2'' adapter for C-8, Meade 2080, etc. ..	**$29.50**
2'' adapter for C-80, C-100 refractor ...	**$39.50**
2'' adapter for C-70, C-80F, C-100F fluorite	**$39.50**
2'' adapter for C-6, Comet Catcher, Meade 312	**$30.00**

EXTENSION TUBES

1'' long 1¼'' OD thread-in extension ...	**12.00**
2½'' long extension (holds 1¼'' filters) .	**19.50**
4½'' long extension for 1¼'' eyepieces	**$29.00**
3'' long extension for 2'' eyepieces* ..	**$29.00**
2'' long extension for 2'' eyepieces* ..	**$29.00**

VIEWING ADAPTERS

2''/1¼'' reducing bushing, threaded 48mm*	**$25.00**
2''/T-thread adapter, threaded 48mm* ..	**$25.00**
T-thread/1¼'' adapter	**$25.00**
F/10 2'' or 1¼'' eyepiece viewing adapter for Giant Easy-Guider	**$39.50**
Low profile star diagonal eyepiece holder	**$16.00**
Meade 2'' Diagonal/Giant Easy-Guider	**$39.50**

**Threaded to hold 48mm filters.*

★ ★ ★ BEST VALUES - LOWEST PRICES! ★ ★ TELRAD ★ PARKS ★ BUSHNELL ★ RIGEL SYSTEMS ★ SCORPIUS ★ ASTRO SYSTEMS ★ SKY PUBLISHING ★ ★ ★

CELESTRON

LOWEST PRICES

IN THIS AD – LOOK

EYEPIECES FROM $12 EA/ FILTERS FROM $9 EA / TELESCOPES FROM $69

(203) 746-3579

LOWEST GUARANTEED LISTED PRICES!

WHO BUYS FROM W.O.?

Bell Labs
NJ
(2) 4 inch MAKS

CELESTRON

$AVE

LATEST MODELS WITH PRICES TOO LOW TO PRINT

TELESCOPES SCH/CASS.

C5 (AC) **C5+** (DC)	
GPC8, **C8 +** Computerized,	
C8+, Ultima C8, C8/11 2000	
CG11, **CG14**, **C14** Computerized	**Lowest Prices**

TELESCOPES REFLECTORS

C4.5, GP 200 7.9" FS 114 6" 8" DOB	from $249

TELESCOPES REFRACTORS

First Scope 80, 60, 90F, GP 102, GP102 ED CO 40	$69

SPOTTING SCOPES - CALL

C90 all models, S50, C60RC, 20x60 WP, 20x60 Ed-WP, 30x60 WP, S80, C5, C8, 500mm. f 5.6	from $208

BINOCULARS - PRICED TO SELL!

Monoculars 8x25.....$38, 6X16 ... $55	**UNBEATABLE**
Mini 8x25, 8x22, 10x25, 8x24PP, 10x24PP...$49	**PRICES**
NATURE 7X35, 7X50,8X42	**ALL OTHERS CALL**
Pro 8x30, 7x50, 10x50, 12x50, 8x56, 9x63, 8-24x50 Zoom	
ULTIMA 8x32, 7x42, 10x42, 7x50, 10x50, 8x56, ED SERIES 6.5x44, 9.5x44	ea $349
Water Proof 8x21, 11x80mm 12X80mm, 20X80mm	

OPTICAL TUBE ASSEMBLIES - IN STOCK

Vixen Fluorite Refractor 70mm ....$995, 9 1/4"	$949
C8" Optical Tube Assem. Star Bgt.	$799
GP 102........$724, C11......$1595, C14	$3895

ULTIMA EYEPIECES

5, 7. 5 12.5 mm.....ea $79, 18mm	$82
24mm, Ultima 1 1/4"	$90
30.........$92, 35.........$108, 42mm	$108
45 mm 2".......$98 80mm 2"	ea. $128
OR 6, 7, 9, 12mm (96")	ea $34
4, 6, 8, 12.5, 20, 25mm (.96) (MH)	ea $12
KE 10mm 16, 18 25 30 40 (96")	ea $33

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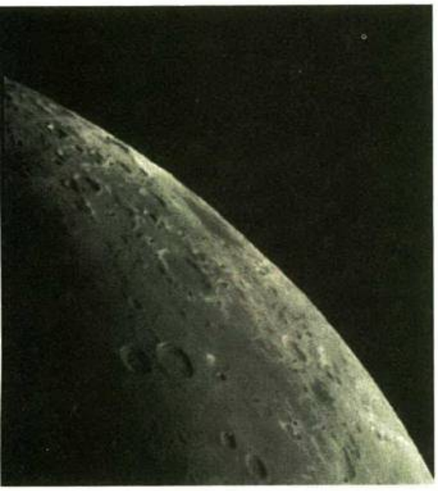

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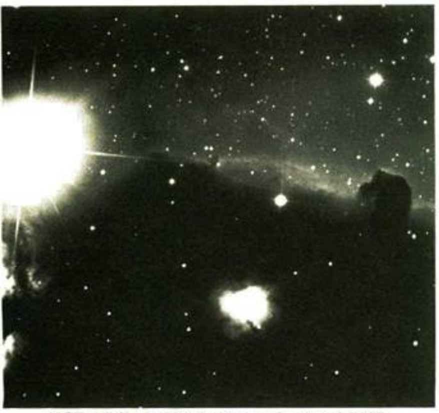

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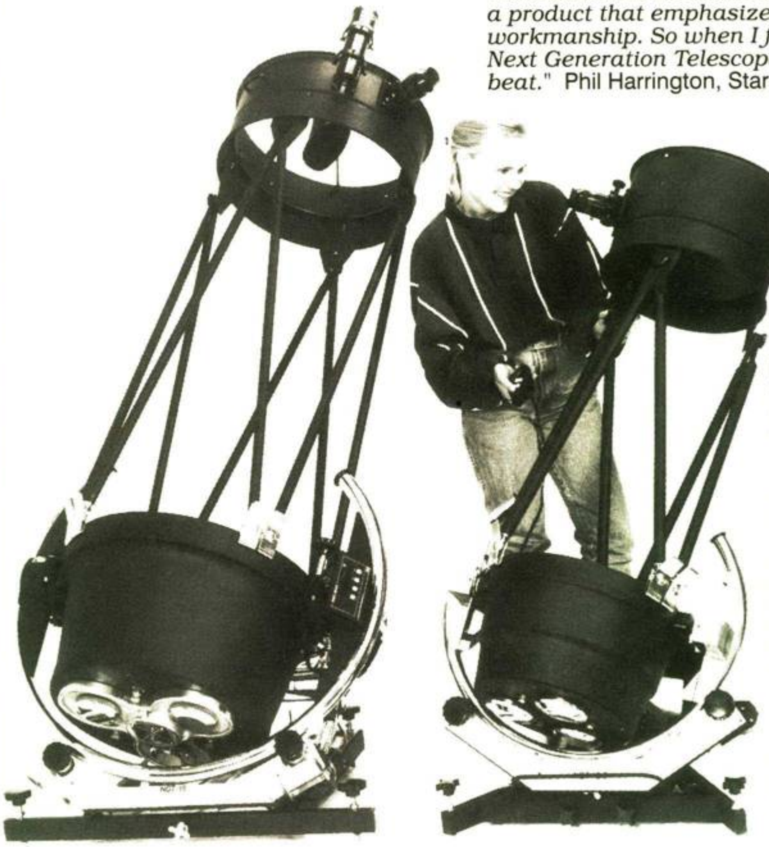

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Melanie Melton, (Kalmbach Publishing Company, 1996), ISBN 0-913135-26-7, 103 pages, paperback, $14.95.

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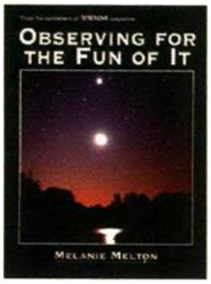

An Observer's Guide To Comet Hale-Bopp

Don Machholz, (MakeWood Products, 1996), ISBN 0-9646487-2-5, 82 pages, paperback, $12.00.

Renowned comet hunter Don Machholz has written a thorough guide that will help you get the most out of what could be one of the best comets of the century. Complete with diagrams and star charts, this book takes you every step of the way to greet our eagerly awaited cosmic visitor. You can order the book through: MakeWood Products, P.O. Box 1716, Colfax, CA 95713, (916) 346-8963, DonM353259@AOL.com.

Gazetteer of Planetary Nomenclature 1994

Raymond M. Batson and Joel F. Russell, editors, (U.S. Government Printing Office, 1995), 295 pages, paperback, $25.00 plus $3.50 for shipping.

If someone tells you to go to Hell, where exactly do they have in mind? The answer — a crater at latitude 34.2° S and longitude 7.8° W on the Moon's nearside — can be found in this useful publication from the U.S. Geological Survey.

The Gazetteer is a kind of phone book of the solar system. It records the latest official names for features on solar system bodies. These features include craters, dunes, valleys, coronae, fissures, bright spots — you name it. The Gazetteer also tells you how big the feature is, gives its geographical coordinates, and provides a minimum of background on the origin of its name. The volume has 1994 in its title because that was the year the International Astronomical Union last officially approved additions to the canon.

You can order this as USGS Bulletin #2129 from USGS Information Services, P.O. Box 25286, Federal Center, Denver, CO 80225; phone (303) 202-4700. (They take plastic.) Or you can surf into http://wwwflag.wr.usgs.gov/nomen/nomen.html.

Alien Horizons: The Fantastic Art of Bob Eggleton

Text by Nigel Suckling, (Paper Tiger Books, 1995), ISBN 1-85028-336-2, 128 pages, softcover, $21.95.

If you love Bob Eggleton's mind-bending paintings in ASTRONOMY, this book is for you. It contains a varied collection of his space art, along with his paintings for science fiction and fantasy books. The book can be ordered through: Bud Plant Comic Art, P.O. Box 1689, Grass Valley, CA 95945, phone: 916-273-2166.

Project Astro How-to Manual for Teachers and Astronomers

Jessica Richter and Andrew Fraknoi, (Astronomical Society of the Pacific, 1996), 42 pages, softcover, request a $5 donation to cover shipping and handling, call (415) 337-1100.

If you have ever considered sharing your time and astronomical talents with school kids but didn't know how to go about it, this manual will guide you to an effective and rewarding interaction. Teachers will find tips on how to form partnerships with local amateur and professional astronomers to increase students' interest in science and astronomy. ☐

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The Asimov Seminar,
White Eagle Conference Center, Hamilton, New York. Contact Doug Loss, The Asimov Seminars, P.O. Box 54, Rensselaerville, NY 12147-0054, (717) 389-4797, loss@husky.bloomu.edu.

July 29-August 17
International Astronomical Youth Camps,
Coucouron, France. Sponsored by International Astronomical Youth Camp. Open to all English-speaking youths ages 16-24. Contact IWA e.V., Gwendolyn Meeus, Schapenstraat 11, 3000 Leuven, Belgium.

August 7
World Decennial Galaxy Party,
Rock Hill, South Carolina. Sponsored by the Galactic Society International. Contact GSI, P.O. Box 326, Rock Hill, SC 29731, (803) 328-0705, 681-0913@mcimail.com.

August 9-11
Stellafane Convention,
Breezy Hill, Springfield, Vermont. Sponsored by Springfield Telescope Makers, Inc. Contact Stellafane Convention, P.O. Box 50, Belmont, MA 02178, http://stellafane.com/~stell/stelfane.htm.

August 9-11
Southern Idaho Regional Star Party,
Bruneau Sand Dunes State Park, Idaho. Sponsored by the Boise Astronomical Society. Contact Sam Johnson, (208) 939-2095, bas@micron.nmet.

August 9-18
Fifth Annual Summer Star Party and Family Camping Vacation,
Shady Pines Campground, 547 Loop Road (Off Rt. 116), Savoy, MA 01256. Sponsored by the Rockland (N.Y.) Astronomy Club. Contact Don Urban, 73 Haring St., Closter, NJ 07624-1709, (201) 768-6575, http://durban1@aol.com.

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MEETINGS EVENTS

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Merritt Reservoir, 27 miles south of Valentine, Nebraska. Sponsored by the Prairie Astronomy Club. Contact Tom Miller, 3400 N. 102 Street, Lincoln, NE 68527, (402) 466-4170.

August 11
The Perseid Meteor Shower,
Washington Crossing State Park, Washington Crossing, Pennsylvania. Sponsored by the Franklin Institute's Fels Planetarium. Recommend reservations by Aug. 5. Contact (215) 448-1369, http:/sln.fi.edu/tfi/info/skywatch.html.

August 14-18
Mt. Kobau Star Party,
near Osoyoos, British Columbia, Canada. Sponsored by the Mt. Kobau Astronomical Society. For more information contact Ann Murphy, MKAS, P.O. Box 20119 TCM, Kelowna, B.C., Canada V1Y 9H2, (604) 764-8478.

August 16-18
Northwoods Starfest,
Hobbs Observatory, Fall Creek, Wisconsin. Sponsored by the Chippewa Valley Astronomical Society. Contact Ray Forsgren, 4856 Inlet Drive, Chippewa Falls, WI 54729.

September 5-8
Huronla Star Party,
Lisle, Ontario, Canada. This event is sponsored by the South Simcoe Amateur Astronomers. Contact Henri Van Bemmel, 1502-140 Erskine Avenue, Toronto, Ontario, Canada M4P 1Z2, (416) 481-9937. □

Please submit club announcements four months in advance to Meetings and Events, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187-1612, or to tconley@astronomy.com.

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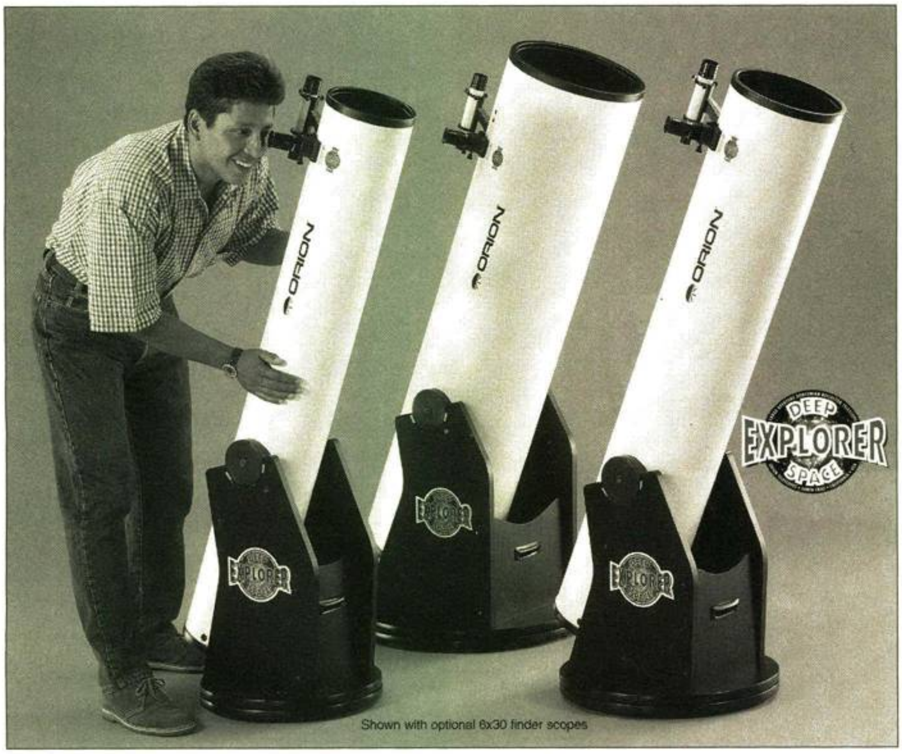

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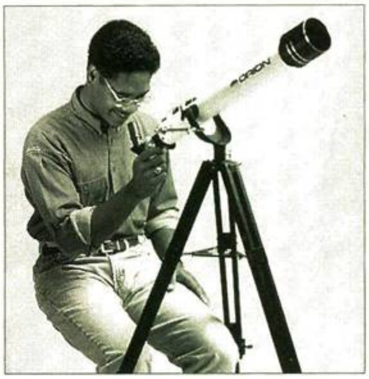

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***Astronomy* (2/91)**

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Many other sizes available. See our free catalog for details.

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.965" Set of 4 #80A Blue, #58 Green, #25 Red, #15 Yellow. #5510

1.25" Starter Set of 4 #80A Blue, #58 Green, #25 Red, #15 Yellow. #5514

1.25" Expansion Set of 4 #21 Orange, #47 Violet, #11 Yellow-Green, #82A Pale Blue. #5516

1.25" Advanced Set of 4 #8 Yellow, #23A Light Red, #38A Deep Blue, #56 Light Green. #5570

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2" Set of 4 Includes #80A Blue, #58 Green, #21 Orange, and #12 Yellow.
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.965" and 1.25" **$14.95**, 2" from **$32.50**

Observing Aids

Orion FlexiShield™ Dew Caps

Fights moisture buildup. Flexible black material fits snugly around scope tube; Velcro fastener. Rolls up or flattens for convenient storage and travel. Models to fit most telescopes.

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9-1/4" Celestron SC	#4214	**$48.95** (2.98)
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11" Dew Zapper fits all Celestron 11" SCs
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Deluxe Tripod and Wedge Bag Fits Ultima tripod with wedge attached.
#15140 **$109** (5.19)

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For 8" DSE	#15181	**$8.95** (2.19)
For 10" DSE	#15182	**$10.95** (2.19)
For 12.5" DSE	#15183	**$14.95** (2.19)
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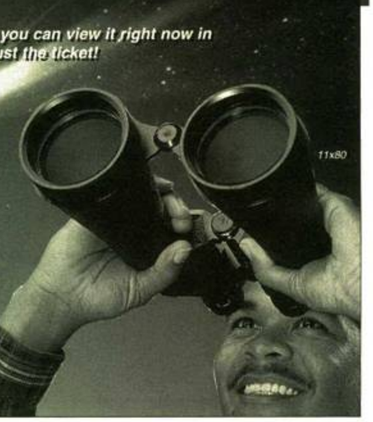

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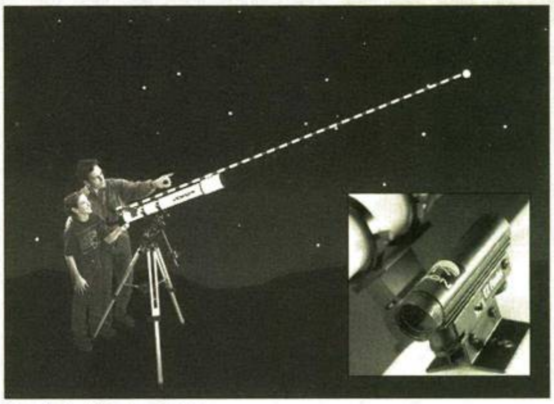

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PHOTOFACTS

p. 69, left: Kim Zussman, eye in the sky, 14.5-inch f/8 Cassegrain, hypered Kodak 2415; **top:** Ivan Dryer, where to begin. No data;

p. 70, left: Lee C. Coombs, a loose globular, 10-inch f/5, 103a-O film, 15 minutes: **right:** Martin C. Germano, a faint planetary, 14.5-inch f/5, hypered Kodak 2415, 55 minutes;

p. 71: Martin C. Germano, a 3-D cluster, 8-inch f/5, hypered Kodak 2415, 30 minutes;

p. 76: Mark Coco, the summer Milky Way, 8mm f/2.8 for 18 minutes on Fujichrome 1600D slide film;

p. 77, bottom: Scott Nielsen, seasonal Sun paths, 15mm f3.5, 27 exposures at 1⁄1000-second each on ISO 50 Fuji Velvia slide film copied onto Kodak duplicating film;

p. 78: Michel Tournay, aurorae over Chisasibi, Quebec in March 1996, 16mm f2.8, 30 seconds, ISO 200 Fuji Super G slide film;

p. 79: Stephen J. Edberg, Perseid meteor search, homemade fish-eye lens for 30 minutes on Ektachrome 400 slide film.

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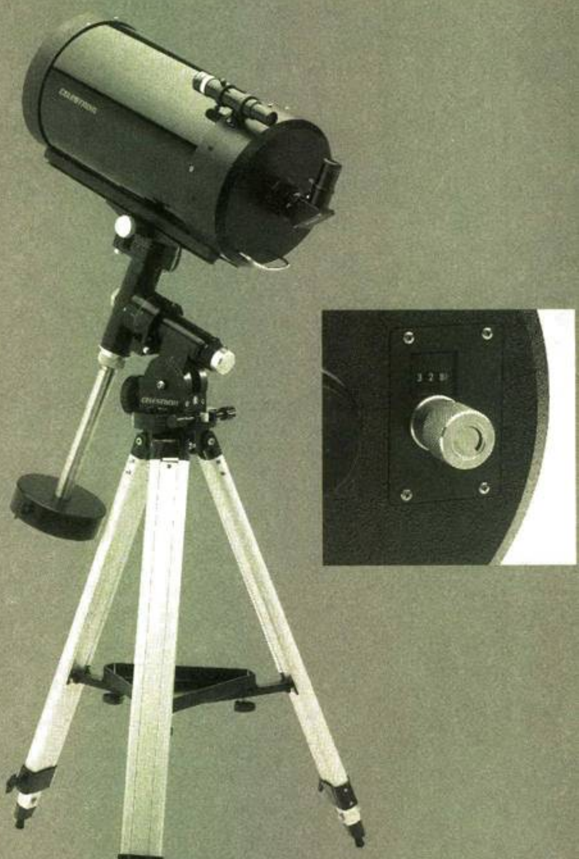
The CG-9¼ dual axis DC electronics are state-of-the-art. Four tracking rates are available: sidereal, King, lunar and solar. It has four setting rates of 4x, 8x, 16x and 32x. Also it has three photo guide rates of ±30%, ±50% and 2x. The electronics have full feature PEC (Periodic Error Correction) built-in. TVC (Time Variable Constant) built-in is a user programmable declination backlash compensation for instantaneous tracking response. *Sky & Telescope* said, "the drive is so accurate that tracking was superb whether or not the electronic PEC feature was switched on."

The equatorial head weighs 21 lbs. without counterweight bar and is the heaviest individual component of this portable telescope. Total weight is 53 lbs.

The mount has an optional polar alignment scope available which works in both hemispheres. The latitude range is 0° to 64°.

With the addition of the optional Advanced Astro Master®, you have a computerized telescope.

Standard accessories included are: 6x30 Finderscope, Star Diagonal – 1¼", and a multi-coated 26mm Plössl Eyepiece – 1¼" (90x). Starbright® coatings are included.



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The equatorial head weighs 31 lbs. and is the heaviest individual component of this portable telescope. Range 12° to 64°.

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Standard accessories include a 7x50 Finderscope, Star Diagonal – 1¼", Visual Back – 1¼" and a multi-coated 26mm Plössl Eyepiece – 1¼" (108x).

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Standard accessories include a 6x30 Finderscope, Star Diagonal – 1¼", Visual Back – 1¼", and a 26mm multi-coated Plössl Eyepiece – 1¼" (78x). Weight of the complete telescope is 45 lbs.

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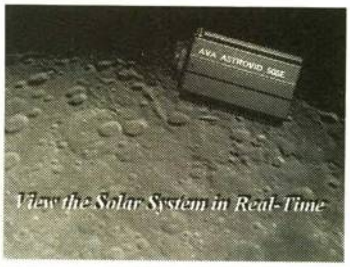

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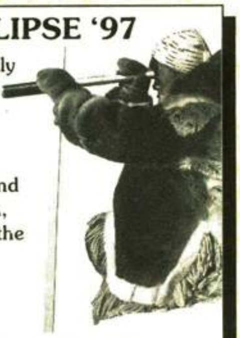

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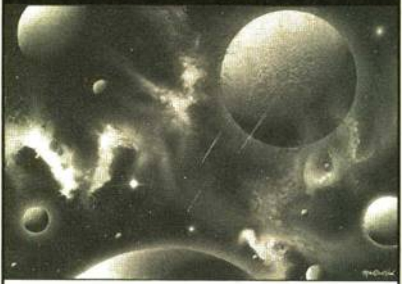

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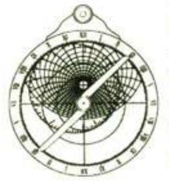

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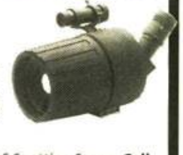

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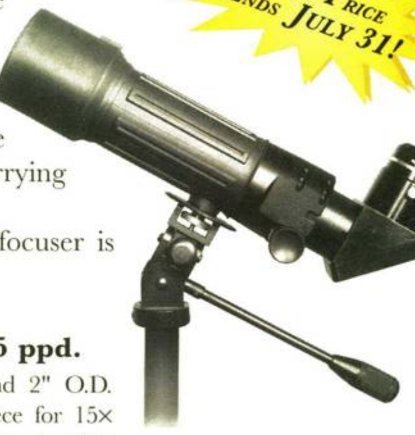

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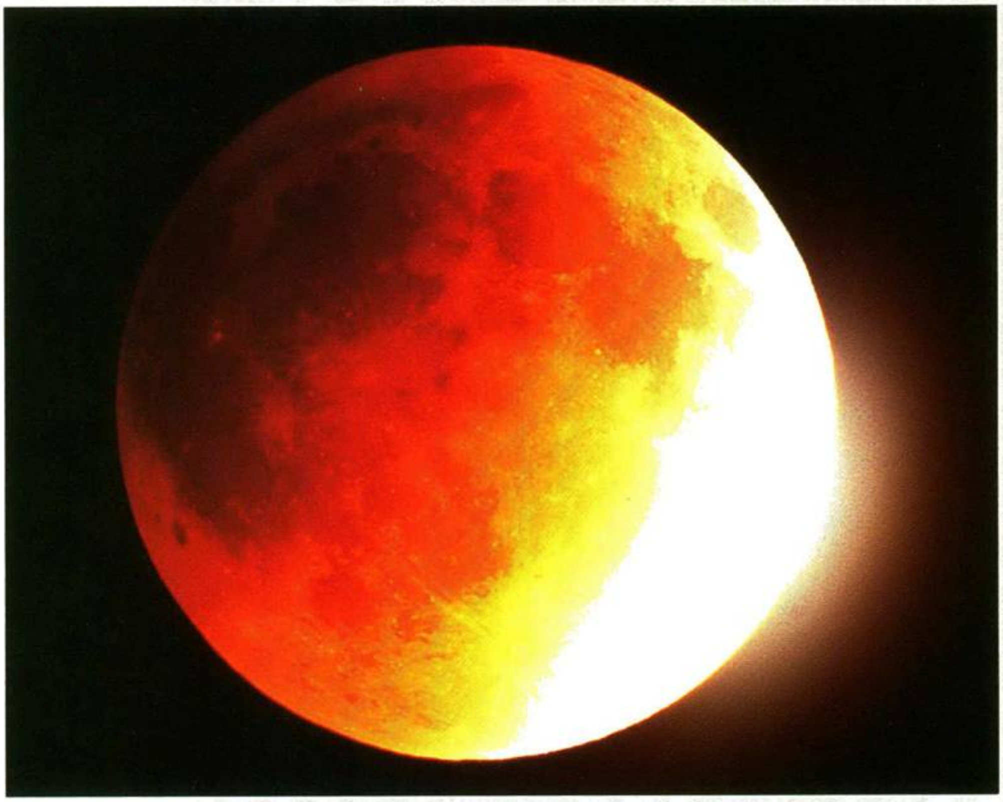
Tale of An Eclipse and Two Comets

On the evening of April 3, 1996, the Moon put on a shadow play. Earth's 16,000-kilometer-wide shadow swept over it, darkening the lunar surface in one of the finer recent lunar eclipses. The event was visible from eastern North America, South America, Europe, Africa, and western Asia. A stream of photos began to pour into the ASTRONOMY editorial office just as the flood of Comet Hyakutake (1996 B2) images started to dry up.

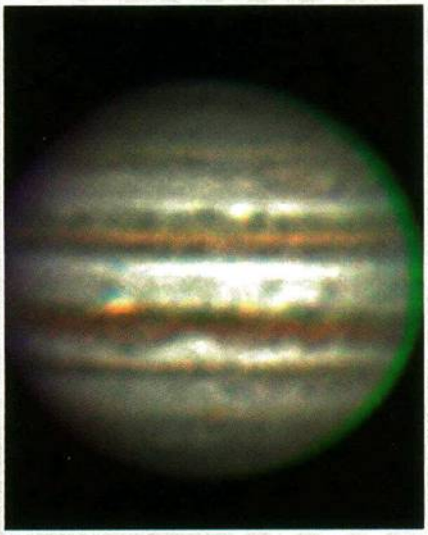
The buzz continued to be the comet, however, at star parties, club meetings, and on Internet news groups. "The coma is very large, circular, with a bright, round, globular-like center," wrote Christopher E. Spratt on March 15. "The comet is visible to the naked eye as a small, bright, elongated ball, its tail stretching 1.5°. In 11x80 binoculars the coma has a very bright center, a filamentary tail with a bright, narrow, central part, and extends 2.5°."

On March 19, George Zay observed the comet from Descanso, California. "Overall, the comet has a bright, starlike nucleus, with a 1°-diameter fuzzball coma. With the naked eye the tail extends about 3° with averted vision. The views in 14x100 binoculars are breathtaking." Less than a week later, the comet exploded in bright-



The Lunar Eclipse of April 3/4, 1996
Pedro Ré
(14-inch SCT at f/6, 10-second exposure taken April 3, 1996)

The Moon Before Mid-Totality
Patrick Martinez
(12-inch f/6 reflector, Ektar 1000 film, 8-second exposure taken April 3, 1996)

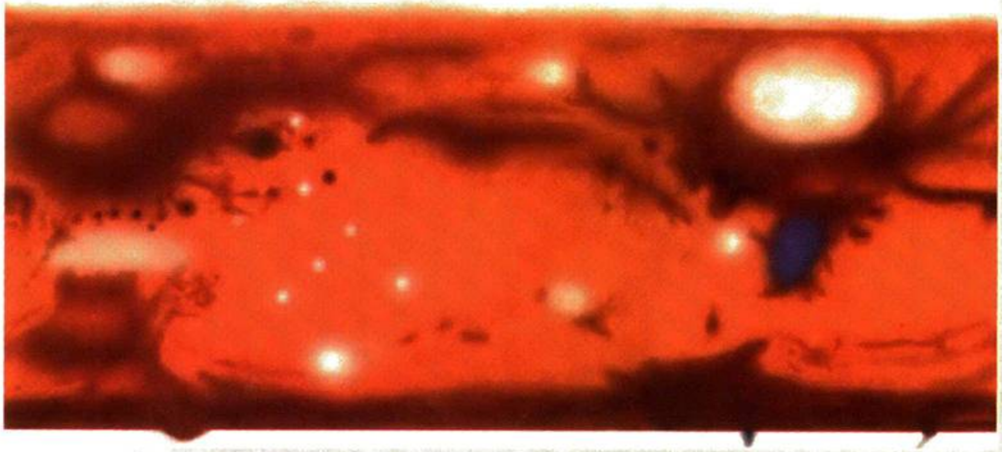


Jupiter's Belts, Spots, and Bands
Don Parker
(16-inch reflector at f/19, Lynxx PC CCD camera, taken April 6, 1996)

ness. On March 23 Robert Stewart of Norfolk, Virginia, reported seeing a 15° tail with the naked eye from the Portsmouth Campus of Tidewater Community College. "Comet Hyakutake continues to put on one of the greatest shows in the heavens," said Tom Randall of Poughkeepsie, New York, on March 26. "Tonight the comet is 2° away from Polaris and is shining at magnitude 0. Watching it creep past stars has been an exciting pastime. At 40x in a 4-inch SCT the comet has a 'spike' coming from its core that is sharply defined and easily visible. What a spectacular show!"

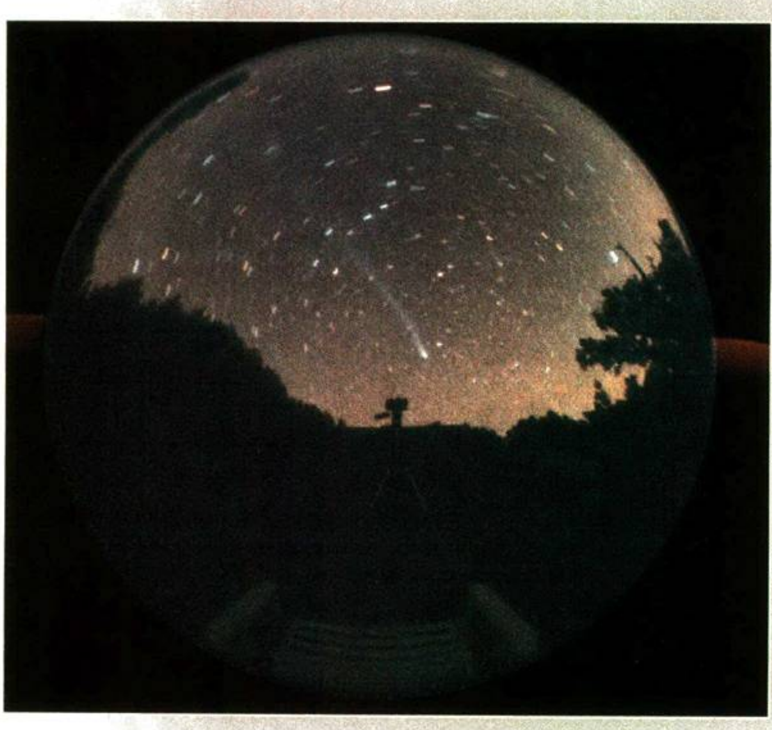
By the end of April Hyakutake was in essence gone, floating just a couple of degrees above the horizon at sunset. Yet its demise signaled the beginning of what may be an even more glorious comet, Hale-Bopp. This comet, visible for months now in telescopes, is rising to naked-eye brightness as it spins northward into Serpens Cauda and Ophiuchus. Should Hale-Bopp live up to its predictions, it will outshine Hyakutake at its peak next spring and become the new comet of the decade.

All-Arizona Messier Marathon. A. J. Crayon of Phoenix reports that on March 16, 1996, several dozen Arizona amateurs held a Messier Marathon, an attempt to see all the Messier objects in one night. Observers from the Saguaro Astronomy Club, the East Valley Astronomy Club, the University of Arizona, and the Tucson Amateur Astronomical Association set up 65 telescopes and went after faint fuzzies. By sunrise, 30 observers remained and turned in observing forms. David Fredericksen won

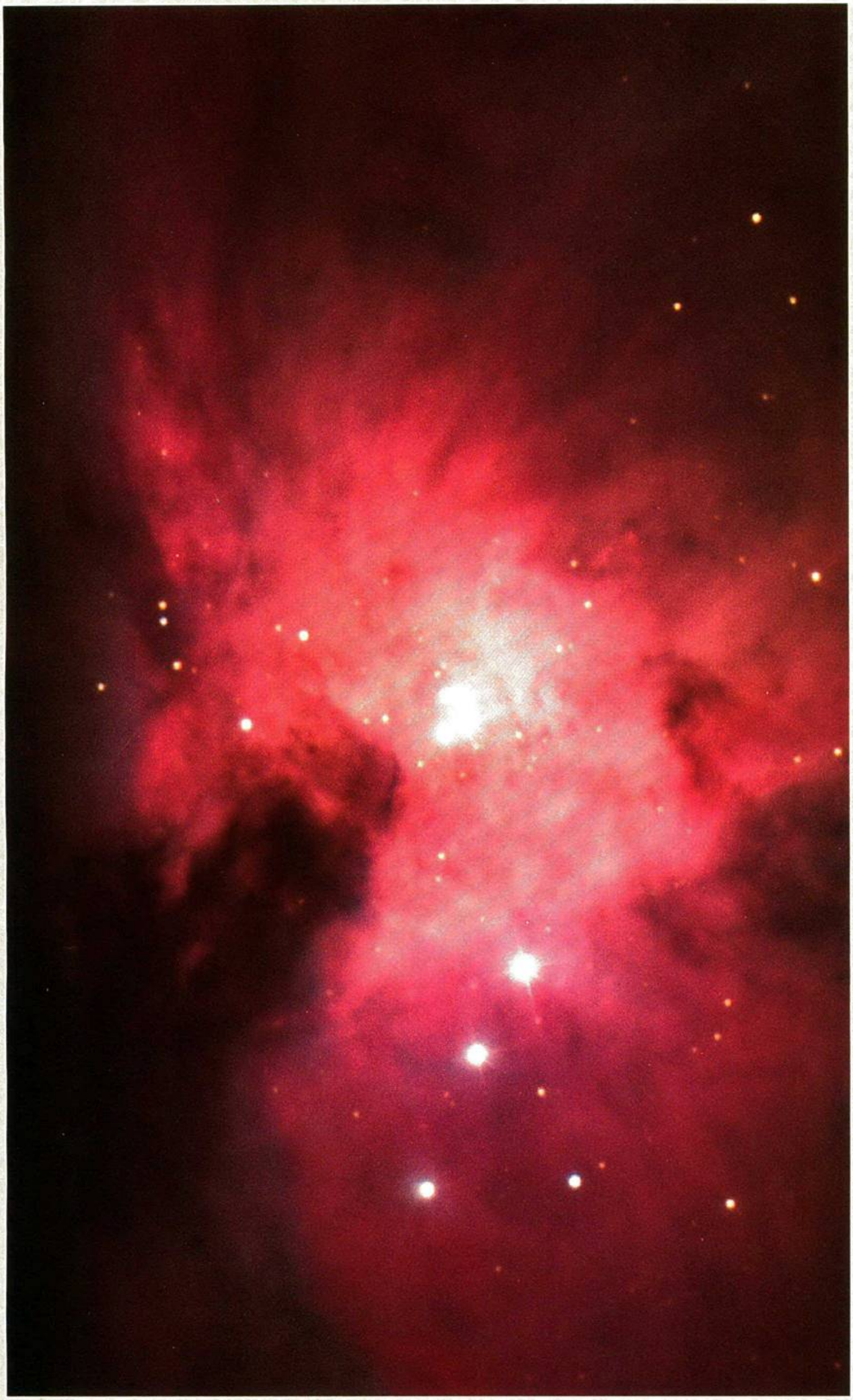


Details from the 1995 Apparition of Mars
Dan Troiani and the ALPO Mars Section Observers
(composite made in Photostyler using the combined observations and data from the ALPO 1995 season of observing Mars)

Jupiter in the Milky Way
Vince and Maggie Farnsworth
(50mm lens at f/2.8, Fuji SG 800 film, 15-minute exposure)



An All-Sky View of Hyakutake
Chris Schur
(135mm lens at f/2.8 aimed into a 12-inch "moon" hubcap, Kodak Royal Gold 1000 film, 20-minute exposure taken March 26, 1996)

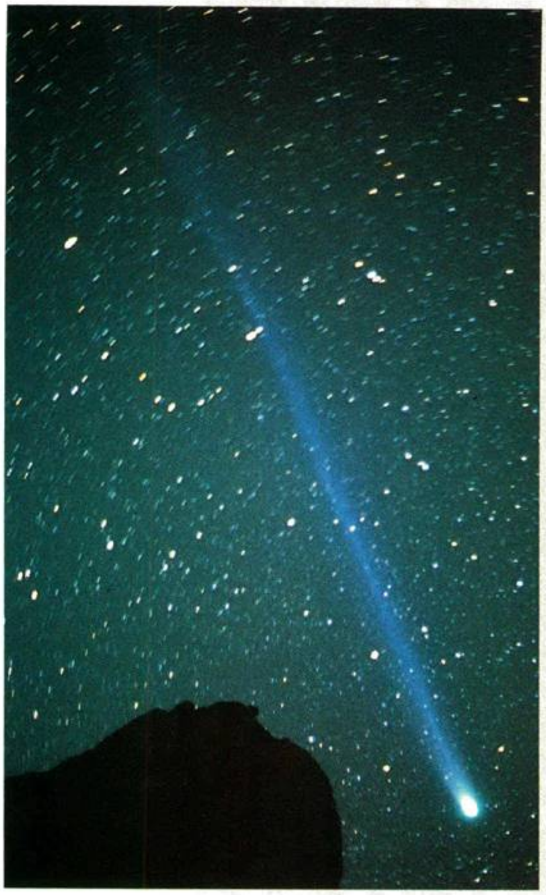


Core of the Orion Nebula

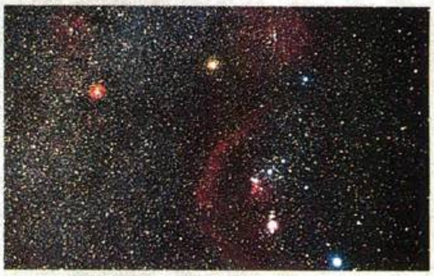
Tony and Daphne Hallas

(42-inch f/8 Cassegrain, Fuji Super HG 400 film, 20-minute exposure taken at Lowell Observatory's Anderson Mesa site) the marathon, having spotted all 110 Messier objects. Crayon, Tom McGowan, Tony Ortega, and Don Wrigley tied for second place (with 109); Carl Anderson, Adam Block, Aaron McNeely, Ken Reeves, Wade Holguin, and Jack Jones placed third (108). □

ASTRONOMY wants to share your observations of the sky with readers. Send reports, sketches, photographs, and disks to David J. Eicher, Reader Reports Editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187–1612. Please label each photo with photo data, name, address, and social security number. You may send written reports and images via the Internet to: rreports@astronomy.com

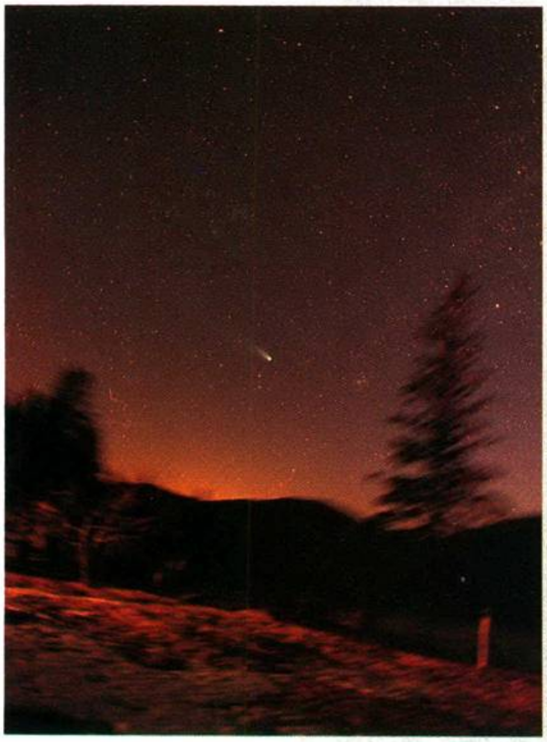


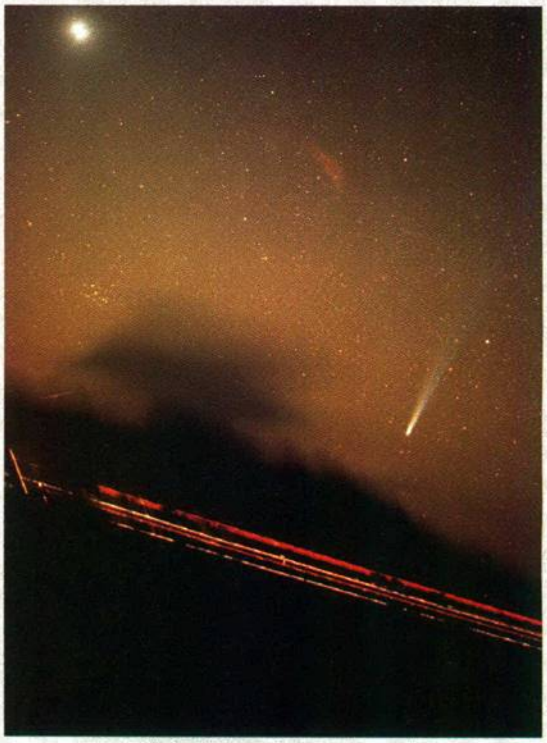
Comet Hyakutake from Jug Handle Arch, Utah
Michael Shin
(50mm lens at f/1.4, Fuji Professional Provia 1600 film, 2-minute exposure taken March 27, 1996)



Orion and Monoceros
Mace Hooley
(50mm lens at f/2.8, composite of two 60-minute exposures)

Hyakutake over Lake Placid, New York
Richard and Phyllis Murphy
(24mm lens at f/2.8, ISO 1000 film, 6-minute exposure taken March 29/30, 1996)

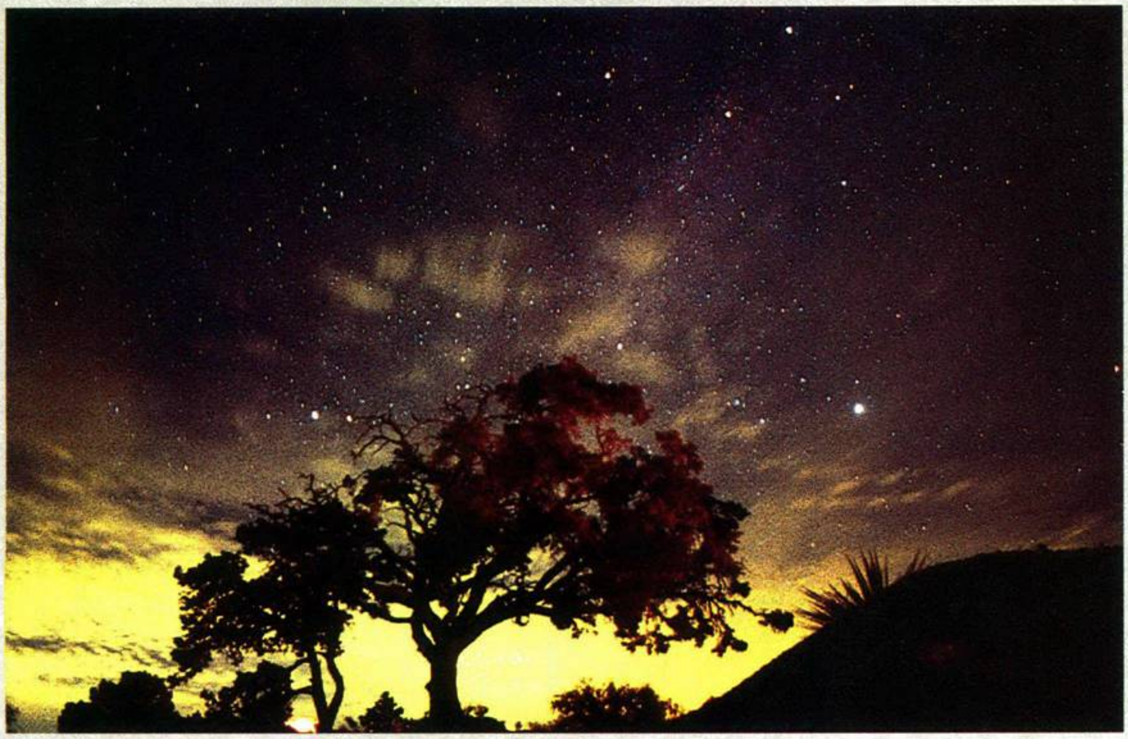




Hyakutake, Venus, the Pleiades, and the California Nebula
Ronald E. Royer
(80mm lens at f/2.8, PPF-2 400 negative film, 15-minute exposure taken April 16, 1996)

Hyakutake in all its Glory
Gerald Rhemann and Franz Kersche
(7.5-inch f/2 Schmidt camera, Kodak Gold 400 film, 4-minute exposure taken April 17, 1996)

Dark Nebula Barnard 72, "The Snake"
Michael Stecker
(5-inch f/6 refractor, hypersensitized Fuji HG 400 film, composite of two 60-minute exposures)



The Summer Triangle and a Pinyon Pine
Jerry Schad
(24mm lens at f/1.4, P1600 film pushed to ISO 3200, 1-minute exposure taken from the Anza-Borrego desert)

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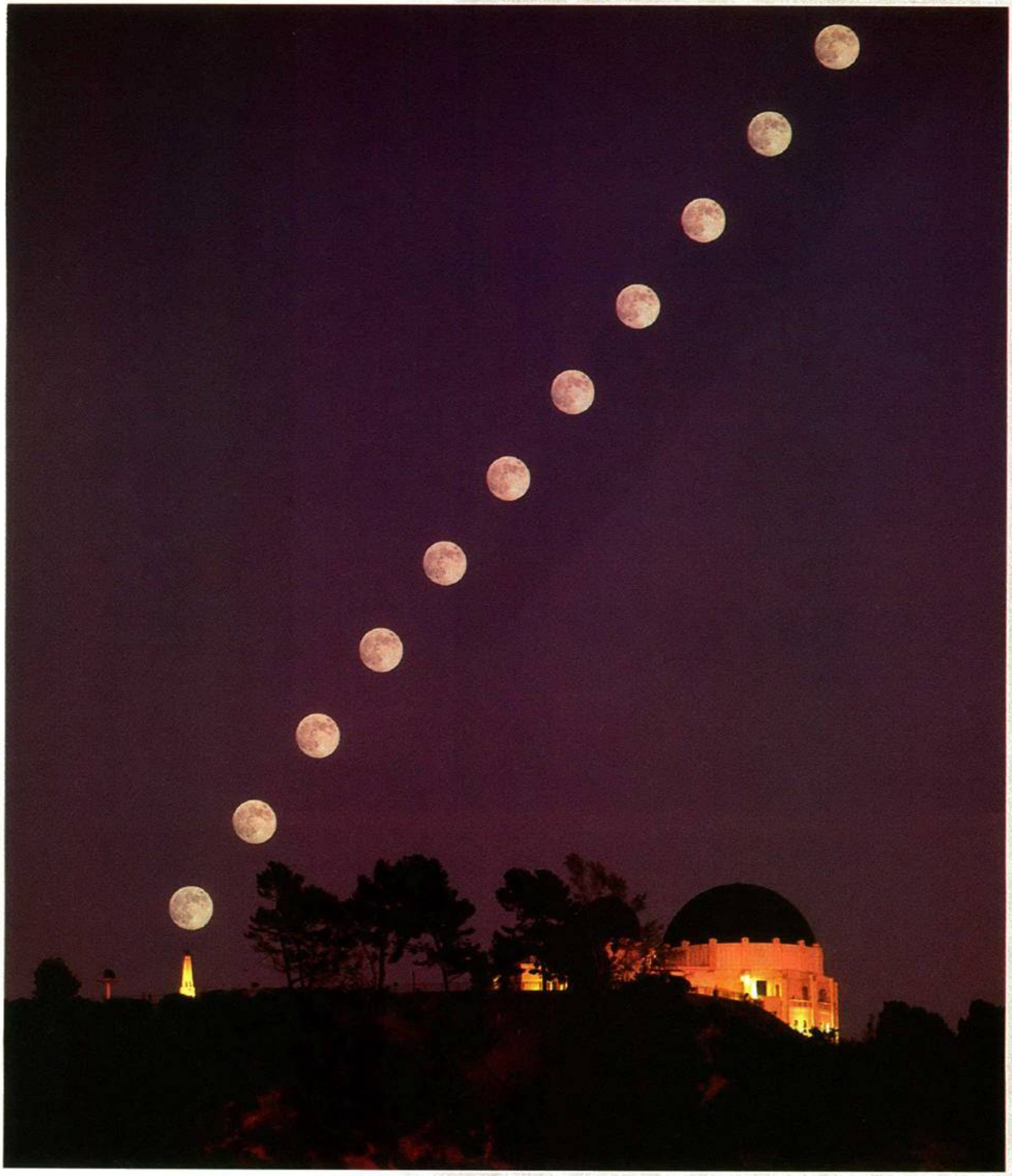

Moonrise Over Griffith Observatory

William Hood

(210mm lens, large-format camera, Fuji Velvia film, multiple exposures taken 5 minutes apart)

Owned and operated by the city of Los Angeles, Griffith Observatory has for decades stood as one of the country's premier sites of astronomy popularization. The observatory features a 12-inch Zeiss refractor and the nearby planetarium houses crowds of enthusiastic stargazers. William Hood of Gardena, California, captured the beauty of Griffith against a rising Moon by taking exposures at five-minute intervals.

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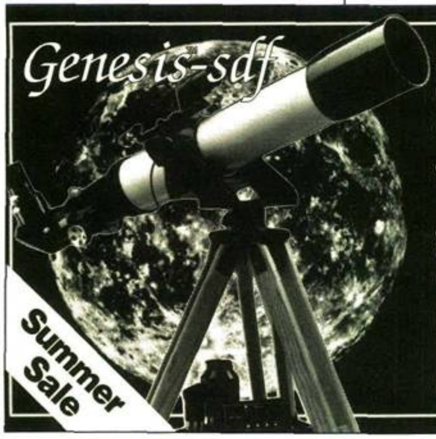

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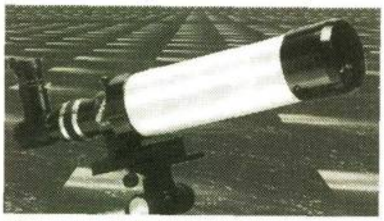

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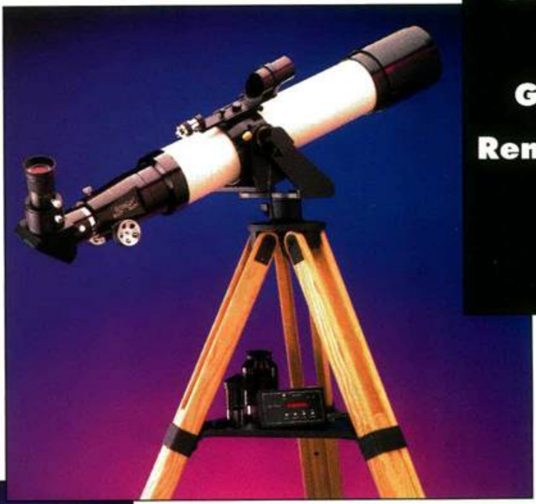
Unforgettable images...both rich-field & diffraction limited...pride of owning a fine piece of American craftsmanship...convenience; These unsolicited sentiments plus those below have been expressed by so many Tele Vue telescope owners. Our goal is to produce scopes rich in value, so you may enjoy exploring all facets of your universe. Call your dealer today and begin an unforgettable journey.



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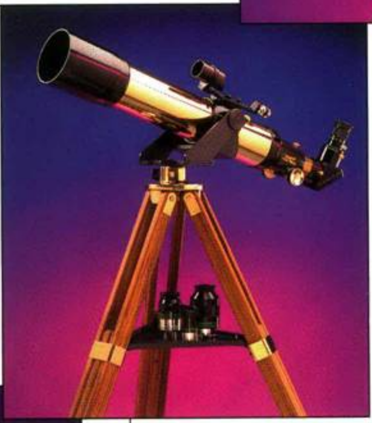
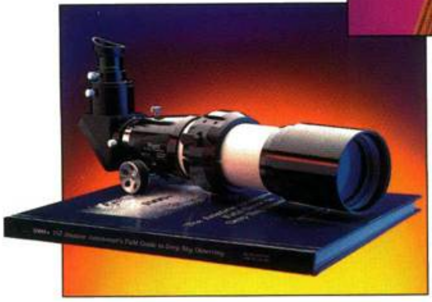


GENESIS/RENAISSANCE-sdf

"...On critical star tests, the Genesis-sdf performed flawlessly...The level of color correction in the SDF was impressive. The edge of the Moon was pure white. Saturn appeared without any trace of a blue halo. This is a superb level of color correction in any refractor, let alone one this fast and portable... Combined with premium wide-angle eyepieces, this is a telescope capable of providing stunning low-power views of Milky Way starfields. And yet under good seeing conditions, the sharp optics will easily handle 200 to 250 power." — Astronomy



I'm amazed at the views! Workmanship excellent - my 8" SCT will gather dust!! R.L. - NH

Wanted high performance APO-Fluorite refractor for wide field views with ultra sharp stars. A fantastic little refractor telescope that I enjoy using more than any other telescope I've ever owned Thank you. JB. - Australia

Probably slightly better than Zeiss APQ, and the one with largest aperture that can be moved by one person only. It's really marvellous. W.D. - Germany

PRONTO

What a great little scope! I found M97, M108, NGC4361, NGC2997& NGC2438 — all from the suburbs. Open clusters look better in my Pronto than in any scope I've ever used. A.E. — AZ

Wow! Perfection in design & quality. Images I only dreamed of. Given a choice of reflectors twice the size, I'll take Pronto. L.R. — CO

The ultimate "shoot & scoot" scope! M.L. — Ont.

Tired of heavy, computerized, SCTs & spending time with them rather than stars. Superb!! Flawless design & performance. What a joy to use. Thanx Al. M.F. — NY

Good sharp view of the Moon & comet Hyakutake. The S&T review persuaded me that going for quality would be good. R.F. - MO

RANGER

" We put Tele Vue's new 70mm f/6.8 refractor through its paces and discovered an ideal travel telescope for astronomy, wildlife, or sports... Saturn's moon Titan as a pinpoint, and a clear edged planetary disc of pale beige yellow with hazy equatorial banding...the tiny, elaborate trapezium of M29 stood out clearly...the companions of Andromeda, M32 and NGC205 showed clearly...the northern component of the Double-Double showed plenty of black space" — Sky & Telescope

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- The **Star Hopper**™ **6"** and **8"** primary mirrors are housed in 8" and 10" ID tubes respectively. The oversized flat black anti-reflective painted tubes reduce light scatter and tube currents. These features increase image contrast and improve "seeing" when viewing planets and the Moon.
- The **V-Spectrum LTM Optical System** features a unique molded **Pyrex** mirror, **multi-coated** for increased reflectivity, that provides superior optical and thermal qualities and it is mounted on the **Pinnacle** mirror cell.
- The **V-Spectrum LTM (Low Thermal Mass)** mirror is manufactured and figured to reach the optimal marriage of weight to optical surface resulting in a mirror with 40% less mass than traditional mirrors. Reducing the mass lowers the "cool down" period required to bring the mirror to ambient temperature and leaves more time for observing. An optional fan can be placed behind the **Pinnacle** mirror cell to create a laminar flow of air over the **V-Spectrum LTM** primary mirror to optimize the mirror for planetary and high power observations.
- Our unique and heavy duty, single vane secondary mirror bracket creates minimal obstruction allowing more light to reach the primary.
- Our unique mount features a 10° angled rocker box which increases stability.
- Ultra smooth motion in both axes for easy finding and observing of objects.
- Included standard are a smooth operating 1¼" Rack and Pinion Focuser, a handy Collimation Tool, 25mm SMA (52°) Eyepiece – 1¼" (49x).
- Numerous accessories are available including various pointing aids — from a traditional 6x30 Finderscope, to a state-of-the-art zero power red dot pointing device — the **Star Pointer**, to the Astro Master® models to computerize your telescope.
- Manufactured at Celestron's factory in the U.S.A.
- All of the above features and yet an economical price.

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C4.5 Its 900mm focal length (f/7.9) optical system is housed in an aluminum tube. The mirrors (primary and secondary) have multi-coatings for improved contrast and resolution. The premium optics are manufactured in Japan to rigid **Celestron** specifications.

The **C4.5** uses the Polaris mount which is a very rigid German equatorial type. The very rigid wood tripod is fixed in height for added stability and is supplied with an accessory tray. A quote from *Astronomy Magazine*, "the **C4.5** stands out from the pack by having by far the best mount. Its Polaris mount is wonderful. Solid. Smooth. And with a damping time of two seconds. It was a joy using this telescope." "This is a first-rate telescope that outclasses the competition in the popular 4½" class of Newtonians." Further they said, "the C4.5 star images were classic textbook Airy disks".

Standard accessories include a 26mm multi-coated Plössl Eyepiece – 1¼" (35x), high quality 6x30 Finderscope and a 1¼" Focuser.

Firstscope 114 Its 910mm focal length (f/8) optical system is housed in an aluminum tube. This high quality yet economical telescope is made in a modern, high quality telescope factory in China to **Celestron's** specifications.

The equatorial mount is stable and includes setting circles in both axes as well as slow-motion cables in both axes for easy tracking. The wood tripod is adjustable in height and includes an accessory tray.

Standard accessories include a 5x24 Finderscope, 1¼" Focuser (with a .96" adapter), 20mm H–.96" Eyepiece (46x), 4mm SR–.96" Eyepiece (228x), 2x Barlow Lens –.96"

A **Firstscope 114 Deluxe** model is available which replaces all .96" accessories with two high quality 1¼" eyepieces – 25mm SMA (36x) and 10mm SMA (91x). The 1¼" accessories give you sharper views, a wider field of view and better eye relief.

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For more detailed information on these telescopes, contact a Celestron dealer or Celestron.

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